Running Head: NEGATION COMPREHENSION AND AGING

Not may not be too difficult: The effects of negation on older adults' sentence comprehension

Sara J. Margolin and Lise Abrams

University of Florida

Please address all correspondence to:

Sara J. Margolin, Ph.D.

Department of Psychology

The College at Brockport, State University of New York

350 New Campus Drive

Brockport, NY 14420-2977

Email: smargoli@brockport.edu

Phone: 585-395-2908

Fax: 585-395-2116

Abstract

The present research investigated the effects of negation on young and older adults' comprehension of sentences. Participants read sentences, named probe words, answered comprehension questions, and completed the operation-span test. Negation adversely affected comprehension in both age groups such that probe word naming times were marginally slower and comprehension accuracy was reduced for negative sentences. Although older adults' comprehension overall was poorer than young adults, the negation effects were similar for both age groups. Furthermore, age was less predictive of negation comprehension than working memory. Unlike other variables that demonstrate age-related declines in reading comprehension, difficulties in processing negation may not increase with age.

Keywords: negation, aging, reading, comprehension

Introduction

Previous research on reading comprehension has shown that relative to young adults, older adults have increased difficulties comprehending texts that tax working memory. For example, when reading some types of texts that are syntactically complex, older adults allocate more time to reading certain portions of the text and have decreased accuracy when retrieving information about the text from memory (e.g., Stine-Morrow, Ryan, & Leonard, 2000). One variable that has not been studied in older adults' reading comprehension is negation. In young adults, sentences including negation, such as *no*, *not*, and *never*, take longer to process, and readers show poorer comprehension when sentences contain negation compared to sentences that do not contain negation (e.g., Cornish, 1971, Experiment 1; Cornish & Wason, 1970; Hoosain, 1973; Just & Carpenter, 1971; Kaup, 2001; Kaup, Dijkstra, & Ludtke, 2004; Kaup, Ludtke, & Zwaan, 2005; Kaup & Zwaan, 2003; Kaup, Zwaan, & Ludtke, 2007; MacDonald & Just, 1989; Sherman, 1973, Sherman, 1976). The present research explored the effect of negation on older adults' sentence comprehension using both activation and content measures.

Activation measures implicitly assess availability of information learned from the text, or how accessible the information is in memory. One measure of activation is response time, where highly accessible information is responded to more quickly. Studies of negation comprehension using activation measures have shown that the presence of negation slows responses times to negated concepts (e.g., Kaup, 2001; MacDonald & Just, 1989; Sherman, 1973). For example, MacDonald and Just (1989) examined the impact of negation on comprehension of a sentence via two activation measures, probe recognition (where participants indicated whether they recognized a word as having been in the sentence they had just read) and probe naming (where participants said the probed word out loud). Results showed that participants' responses to both recognizing and naming a probe were slower if the probe word had been negated in the previously-read sentence. These results suggest that negation may reduce the accessibility of negated concepts in the mental representation and demonstrate one way that negation may be processed.

In contrast, content measures assess the kinds of information that has been retained from the text by asking readers to explicitly retrieve information from memory after reading is complete. Presence of negation in text has been shown to decrease accuracy of comprehension questions and memory retrieval involving negated concepts (e.g., Cornish & Wason, 1970; MacDonald & Just, 1989). Using a verbatim recall test, Cornish and Wason (1970) showed that affirmative sentences (e.g., "It is bright") were recalled more often than the negative sentences (e.g., "It is not bright"). The implications of these results are that negation may not only make ideas less accessible during reading but may also make ideas more difficult to store and retrieve from memory.

Why is negation more difficult to comprehend? One explanation involves deactivation of a concept. MacDonald and Just (1989) proposed that when we read negation, all ideas that are negated become deactivated. For example, after reading the statement "Elizabeth baked some bread but no cookies," "cookies" becomes deactivated and therefore would not be included in the memory representation of the text. Others have suggested that a negative sentence, a type of complex sentence, is processed by transforming the negative sentence into its *kernel*, or affirmative form (e.g., Gough, 1965, Mehler, 1963). Then, upon recall, both the kernel and a note about the transformation that took place are retrieved. Both rationales involve working memory, which is critical for reading comprehension (e.g., Just & Carpenter, 1992). Just and Carpenter (1992) proposed that the amount of information that can be held in working memory, i.e., capacity, influences the degree of comprehension during reading. However, there is an inherent limit to how much working memory can hold. Difficulties arise when the capacity needed to comprehend a sentence exceeds an individual's working memory capacity. Negation may be particularly taxing to working memory, as processing negation may involve more steps than reading non-negated text, whether deactivating a concept or transforming a sentence. In both cases, additional time and processing resources are needed to appropriately store the negated concept in memory, which makes processing of negation more difficult.

Given the necessity of working memory for comprehending negation, older adults may have greater difficulty comprehending negation than young adults, as older adults' working memory resources are thought to be more limited than those of young adults (e.g., Light, 1988; Waters & Caplan, 2001). Although there are no published studies of older adults' comprehension of negation, older adults do show impairments in comprehension when working memory demands are increased, such as when reading syntactically complex sentences (e.g., Kemper, 1987; Norman, Kemper, & Kynette, 1992; Norman, Kemper, Kynette, Cheung, & Anagnopoulos, 1991; Stine-Morrow, Loveless, & Soederberg, 1996; Stine-Morrow et al., 2000; Waters & Caplan, 1996). One recent study has demonstrated that working memory is a significant predictor of older adults' reading comprehension performance and predicted more variance in reading comprehension than did age (e.g., DeBeni, Borella, & Carretti, 2007).

A secondary issue involves the level of representation at which negation has its greatest effects. The Construction Integration (CI) Model (Kintsch, 1998) describes three levels of representation that a text can take in memory. The first of these representations is the *surface level*, where the representation is only the verbatim words themselves. The second level is the *textbase level*, which represents the verbatim words as well as their meanings. The highest level of representation is the *situation model*, including the meaning of the text as well as conclusions and inferences drawn from the text (see also Zwaan & Radvansky, 1998). There is evidence that older adults are better able to understand and store text at the situation level than at the surface and textbase level, while young adults are able to store text at the surface and textbase levels (e.g., Radvansky, Zwaan, Curiel, & Copeland, 2001). Furthermore, Kaup (2001) has shown that in a probe recognition task, negation had greater effects on comprehension of text at the situation model level than the surface level. Therefore, the influence of negation on older adults' comprehension may be especially apparent at the situation model level.

Method

Participants

Fifty-four young (40 female and 14 male) and 54 older adults (35 female and 19 male) were tested. The young adults ranged from 18 to 23 (M = 19.09, SD = 1.22) years of age and were recruited from introductory psychology classes at the university. They received partial course credit for their participation. The older adults ranged from 64 to 87 (M = 74.59, SD = 5.98) years of age. The older adults were community-dwelling older adults, recruited from churches, clubs, and libraries surrounding the University of Florida, and received monetary compensation for their participation. Participants were fluent speakers of American English and reported that they not previously read the “Harry Potter” series by J.K. Rowling or seen the corresponding movies.

Materials

One hundred and two experimental sentences were used in the present experiment. Experimental sentences came from the “Harry Potter” series by J.K. Rowling. This series was selected as text that both young and older adults would like to read, based on an article in the

Gainesville Sun newspaper that reported “Harry Potter” as one of the young adult books that other age groups are beginning to enjoy reading (“Grown-ups are turning to teen books,” 2006). The names of characters were changed to obscure the source of the text and to avoid participants bringing preexisting ideas about what they would be reading. Sentences were also modified to include or exclude negative modifiers, and changes in grammar were made as necessary. A negative modifier was defined as a word that implied the absence of or the opposite of the word that it modified. Modifiers included “no,” “not,” and “never,” with “no” used in 11.7% of sentences, “not” in 87.3% of sentences, and “never” in 1.0% of sentences. Each sentence (e.g., “Adriana's witchcraft competition team was seated at the head table in the dining hall, so this table was not noisy in comparison to the others.”) contained a target word, e.g., "noisy.” Each target was preceded by either a negative modifier as in the above example, where the negative modified the word that followed it, or no modifier, as in the case of the non-negative sentences. When present, the negative modifier was on average 8.2 words away from the end of the sentence. It is important to note that the negative and non-negative sentences differed only by the presence of a negative modifier (as well as some occasional small changes in wording to correct grammar), but were similar in all other ways, including sentence structure, syntactic complexity, and number of words in each sentence ($M_{\text{negative}} = 25.7$, $SD = 4.4$; $M_{\text{non-negative}} = 24.5$, $SD = 4.7$). Additionally, ratings on readability (i.e., how easy the sentence was to read) and awkwardness (i.e., how much sense the sentence made both in terms of structure and content) were obtained from eight raters, using a scale from one to five, where five represented the highest degrees of readability and awkwardness. Negative ($M_{\text{readbility}} = 4.8$, $SD = 0.3$; $M_{\text{awkwardness}} = 1.4$, $SD = 0.4$) and non-negative ($M_{\text{readability}} = 4.9$, $SD = 0.2$; $M_{\text{awkwardness}} = 1.2$, $SD = 0.3$) sentences were rated similarly.

Each sentence was associated with three possible probes for the naming task: verbatim, related, and new. The verbatim probes were the target words from the sentences that were modified by the negation and were thought to measure text represented at the surface level. The related probes were designed to capture representation at the situation model level by using words semantically related to the target, e.g., “loud,” specifically synonyms as defined by a thesaurus that could replace the target in the text without a change in meaning. The new probes were words that were not present in the sentence, were unrelated to the situation described by the text (e.g., “stern”), and could not replace the target word in the sentence without a significant change in meaning. All probe types were relatively high in Francis and Kucera (1982) frequency (M = 163.15) and were similar in length in letters (M = 6.67). The presentation of each type of probe word was counterbalanced across participants, along with negative modifiers and no modifiers, creating 6 versions of stimuli with 17 sentences in each condition. Each sentence was also associated with one comprehension question, specifically focusing on the portion of the sentence containing the target word. In addition, 30 easy, non-negative filler sentences, with probes of all three types and comprehension questions, were presented to hide the pattern of questions always referring to the negative portion of the sentence.

Young and older participants were tested on several measures of cognitive ability, including a 25-item multiple-choice vocabulary test and an Operation Span task (Turner & Engle, 1989) to provide a measure of working memory capacity. Participants also completed questionnaires on other background demographics, including questions about their education, reading, and writing habits. In addition, older participants completed a test of mental status known as the Mini Mental State Examination (Folstein, Folstein, & McHugh, 1972), a 30-point questionnaire surveying older adults' orientation, attention and calculation, recall, and language processing abilities, where all older participants scored at least 27 (M = 28.8, SD = 1.2).

For the Operation Span task, participants were presented with a math equation to verify (e.g., Is (9/3)-2=3?), followed by a word to remember. These were presented in sets of two to five equation-word pairs, with set size presented in the same random order for all participants (stimuli was the same as was used in Turner & Engle, 1989). Participants were then prompted to recall out loud the words from each set. This process was repeated for 12 sets (three sets of each size from two to five words), the proportion of words recalled from each set was calculated, and the average of these proportions was calculated to make each participant's final operation span score. Although there are other scoring methods, this method was chosen because it was a straightforward measure of how many items participants could recall (Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005 present a summary of scoring techniques).

Both the Operation Span task and the experimental tasks were administered on a Gateway E-series Pentium 4, 1.8 GHz PC, using programs written in Visual Basic 5.0.

Design

The present experiment used a 2 x 2 x 3 factorial design with age group (young and older), sentence type (negative and non-negative), and probe type (verbatim, related, and new) as factors. Sentence type and probe type were within-subjects factors, and age group was a between-subjects factor. The dependent variables were the mean naming times for the probe words and percent correct accuracy in answering the comprehension questions.

Procedure

Upon beginning the experiment, older adults completed the MMSE screening. All participants then received instructions on the experimental tasks (to be described below) and completed three practice trials. Following the practice trials, data collection began for each of 132 trials (102 experimental and 30 filler trials randomized for presentation). Each trial consisted of the reading task, the naming task, and one comprehension question. The tasks were completed as follows.

The first task was the self-paced reading task, where participants read sentences one word at a time by pressing the “space bar” with their dominant hand to move from one word to the next. Sentences appeared on the screen with letters replaced by dashes while preserving spaces and punctuation. With each key press, one word was revealed while the previous word returned to dashes. After reading the final word in each sentence, a 500 msec pause was presented, and participants were presented with one of three possible probe words (verbatim, related, and new) for the naming task. Upon presentation, participants said aloud the word shown. The multimedia sound recorder in Visual Basic began timing upon word presentation and stopped recording after the word was spoken, resulting in a .wav file recorded for each word. The naming latency, i.e., the time between probe presentation and the onset of the participants’ voice, was extracted from the waveforms by visual inspection. After naming, participants pressed the “enter” key to immediately show a comprehension question. This question was answered verbally, using one or more words, and the experimenter recorded the answers. After answering this question and pressing the “enter” key, the next sentence appeared on the screen. The process was repeated for all 132 sentences.

When all of the sentences had been presented and the naming and comprehension trials were completed, participants completed the background questionnaires and cognitive tests, as described earlier. After these cognitive tests, participants were debriefed and thanked for their participation.

Results

Demographic and Cognitive Measures

Independent samples t-tests on the demographic measures (means and standard deviations are shown in Table 1) indicated that older adults had more years of education, $t(106) = 9.21$, $p < .01$, had greater vocabulary scores, $t(104) = 15.20$, $p < .01$, and reported spending marginally more time watching television, $t(105) = 1.94$, $p < .06$, and doing crossword puzzles, $t(105) = 1.74$, $p < .09$, than young adults. However, young adults reported spending more time writing, $t(104) = 5.79$, $p < .01$, than older adults. Both young and older adults rated themselves similarly on health, $p > .59$, and reported spending similar amounts of time reading, $p > .35$. For the Operation Span test, young adults recalled a higher proportion of words than older adults, $t(105) = 4.10$, $p < .01$, suggesting that older adults had smaller working memory capacities.

Probe Naming Times

Any inaccurate responses, including those where a participant laughed, stuttered, coughed, cleared their throat, or pressed the "enter" key before they said the probe word, were not included, eliminating 17.3% of potential responses from young adults and 16.0% of potential responses from older adults. The majority of these eliminations were from instances where participants pressed the “enter” key before they said the probe word, indicating an error in their motor processing of the procedure, rather than an error in comprehension or problem in identifying the word that was on the screen. Outliers in participants' naming times (i.e., the latency between the onset of the probe word and the time the participant began saying the word) were accounted for by excluding naming times plus or minus three standard deviations from the mean of each age group. This method excluded 1.8% of the data for each age group.

A 2 (Age Group) x 2 (Sentence Type) x 3 (Probe Type) ANOVA was conducted on mean naming times to determine the availability of the probe words in memory after having just read a negative or non-negative sentence. Table 2 shows means and standard deviations of these naming times. This analysis revealed a main effect of age group, $F(1, 106) = 4.31$, $MSE = 97162.48$, $p < .04$, where older adults had longer naming times ($M = 789.10$) than young adults ($M = 738.26$). In addition, a main effect of probe type, $F(1, 106) = 36.02$, $MSE = 2603.96$, $p < .01$, showed that both verbatim ($M = 740.39$) and related probes ($M = 770.07$) had faster naming times than new probes ($M = 780.57$), *p*s < .01. Verbatim probes were also named more quickly than related probes, $p < .04$. Finally, there was a marginally significant main effect of sentence type, $F(1, 106) = 2.72$, $MSE = 2339.81$, $p < .10$, where probes following negative sentences ($M = 766.81$) had slower naming times than probes presented after non-negative sentences ($M = 760.54$). No interactions among any of the variables were significant, *p*s > .19.

Comprehension Accuracy

Comprehension accuracy was coded to indicate whether an answer was either correct or incorrect. Correct responses included answers that used either the verbatim words from the sentence or synonyms of the words in sentence, as long as the answer captured the meaning or the gist of what happened in the sentence. Answers that were the opposite of or different from what happened, off the topic from what happened, or indicated that the participant did not know the answer (as self-reported by the participant) were marked as incorrect.

A 2 (Age Group) x 2 (Sentence Type) ANOVA was conducted on mean accuracy in answering the comprehension questions, which focused on the portion of the sentence containing the target. The means and standard errors are displayed in Figure 1. This analysis revealed a main effect of age group, $F(1, 106) = 7.31$, $MSE = .023$, $p < .01$, such that older adults had poorer accuracy overall (*M* = 68.0%) on the comprehension questions than did the young adults (*M* = 73.5%). In addition, a main effect of sentence type, $F(1, 106) = 19.29$, $MSE = .007$, $p < .01$, showed that participants' accuracy was poorer for negative sentences (*M* = 68.3%) than for non-negative sentences (*M* = 73.3%). The interaction of the two variables was not significant, $p > .53$.

To determine the influence of working memory capacity on comprehension accuracy in contributing to the main effect of age group shown above, an ANCOVA analysis was conducted with age group and sentence type as variables, as in the above ANOVA, but including Operation Span score as a covariate. No significant differences based on age group (M_{older} adjusted = 69.2%, M_{young} adjusted = 72.1%), $F(1, 104) = 1.90$, $MSE = .02$, $p > .17$, nor an interaction of age group and sentence type, $F < 1$, were revealed, showing that the age difference in comprehension accuracy disappeared when working memory between the age groups was equated.

A stepwise regression analysis was then conducted to examine the degree of working memory's influence on comprehension accuracy and to determine if any other variables explained variance in comprehension (see Table 3). Operation span and age were entered as the first variables because of the theoretical implications of each of these variables on comprehension. The remaining variables entered were vocabulary score, years of education, and time spent reading each day. For both types of sentences, only operation span score accounted for a significant amount of variance for both negative, $R^2 = .13$, $p < .01$, and non-negative sentences, $R^2 = .17$, $p < .01$. No other variables entered into the regression model. Additional regression models were explored, including exploring the impact of the difference in education first, but the same results were obtained. Working memory was the most, and only, significant predictor of performance in this comprehension task.

Discussion

Negation detrimentally impacted reading comprehension in both age groups via activation measures (probe naming times) and content measures (comprehension accuracy), consistent with previous work in negation comprehension (e.g., Cornish, 1971, Experiment 1; Cornish & Wason, 1970; Hoosain, 1973; Just & Carpenter, 1971; Kaup, 2001; Kaup et al., 2004; Kaup et al., 2005; Kaup & Zwaan, 2003; Kaup et al., in press; MacDonald & Just, 1989; Sherman, 1973; Sherman, 1976). In the present experiment, the presence of negation within sentences marginally increased naming times of a probe word and significantly decreased comprehension accuracy. However, aging did not differentially increase difficulties with comprehending negation; both young and older adults were adversely affected by negation to the same degree. This occurred despite older adults having slower naming times and poorer comprehension accuracy overall than young adults, consistent with other research (e.g., Kemtes & Kemper, 1997; Stine, 1990; Stine-Morrow et al., 1996).

Content measures such as comprehension require retrieving information from memory after reading the sentences has been completed, which may be especially difficult for older adults because of their reduced working memory capacities (e.g., Light, 1988; Waters & Caplan, 2001). In accordance with this view, the regression analyses demonstrated that working memory accounted for the most variance in comprehension accuracy, for both negative and non-negative sentences. This finding suggests that working memory, rather than age per se, was more critical for comprehension accuracy in the present experiment. However, the finding that working memory did not explain more variance in comprehending negative sentences than non-negative sentences suggests that working memory may not be excessively taxed by the negative sentences presented here. While working memory is a primary determinant of comprehension accuracy (e.g., DeBeni, et al., 2007; Just & Carpenter, 1992), the regression analysis indicates that there is considerable variance unaccounted for, suggesting that many other factors may be useful in understanding how negation is processed, such as metacomprehension skills of the reader (e.g., DeBeni, et al., 2007), the context in which the negation appears (e.g., Giora, Fein, Aschkenazi, & Alkabets-Zlozover, 2007), the type of text, such as expository or narrative (e.g., DeBeni et al., 2007), and the consistency between the negation and the situation described by the text (e.g., Johnson-Laird & Tridgell, 1972).

With respect to the activation measure, negation marginally slowed probe naming times. However, the effects of negation on activation measures were smaller than the content measures, possibly because the content measures were reliant on memory and thus more susceptible to demonstrating that the readers had a poor representation of the negation stored in memory. The activation measure was sensitive to the different levels of representation, as naming times for verbatim and related probes were faster than new probes. Readers had the fastest access to the verbatim probes, compared to related probes, suggesting that their representation of these sentences was stronger at the surface level of representation. In the present experiment, readers may not have completed their representation at the situation model level for several reasons. First, sentences were presented in word-by-word manner, drawing participants' attention to the individual words in the text. The probe word naming task may have furthered focused their attention to the individual words given that the exact word was used as a probe 1/3 of the time. Finally, the text was only single sentences, such that a general context was not provided. All of these factors may have encouraged participants to process the text at a surface-level representation, which masked the potential for negation effects to emerge at different levels, contrary to previous work showing greater effects of negation at the level of the situation model (e.g., Kaup, 2001).

The present research also demonstrated the impact of negation when reading narrative-type sentences. Some of the previous research on negation dealt with text that more closely resembled logic statements. For example, Cornish (1971, Experiment 1) had participants compare negated sentences to a multi-colored circle (e.g., participants verified the sentence “The dot is not red” in reference to a picture they saw). These experiments may actually be testing logic in that comparing sentences to pictures may be more reminiscent of “if-then” reasoning than reading comprehension. However, these are not the ways in which readers normally encounter negation. Given that the negation effects in the present experiment were relatively small (approximately 5% in comprehension accuracy and 6 msec in probe naming time) and did not increase with age, there may be positive implications for older adults' ability to process negation in everyday life, such as through reading a novel, newspaper, or even a prescription label. Negation may be more difficult for older adults only in specific situations, such as confusing circumstances (e.g., logic games), when they think it is more difficult (e.g., self-fulfilling prophecy), or when more than one negation is present (e.g., Hoosain, 1973; Sherman, 1976).

Given that readers of all ages have some difficulty understanding text that contains negative words, both readers and writers need to be sensitive to the use of this construction. Readers need to learn how to adjust their reading strategies when encountering this construction, and writers should avoid using negation to minimize comprehension difficulties whenever possible. Negation appears in many everyday situations, and future research should explore whether age exacerbates difficulties in comprehending negation in other contexts.

References

Conway, A.R.A., Kane, M.J., Bunting, M.F., Hambrick, D.Z., Wilhelm, O., & Engle, R.W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, *12*, 769–786.

Cornish, E. R. (1971). Pragmatic aspects of negation in sentence evaluation and completion tasks. *British Journal of Psychology*, *62*, 505–511.

Cornish, E. R., & Wason, P. C. (1970). The recall of affirmative and negative sentences in an incidental learning task. *Quarterly Journal of Experimental Psychology*, *22*, 109–114.

DeBeni, R., Borella, E., & Carretti, B. (2007). Reading comprehension in aging: The role of working memory and metacomprehension. *Aging, Neuropsychology, and Cognition*, *14*, 189-212.

Francis, W.N., & Kucera, H. (1982). *Frequency analysis of English usage: Lexicon and Grammar*. Boston: Houghton and Mifflin.

Folstein, M.F., Folstein, S.E., & McHugh, P.R. (1975). Mini–mental state: A practical method for grading the state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

Giora, R., Fein, O., Aschkenazi, K., Alkabets-Zlozover, I. (2007). Negation in context: A functional approach to suppression. *Discourse Processes*, *43*, 153-172.

Gough, P. B. (1965). Grammatical transformations and speed of understanding. *Journal of Verbal Learning and Verbal Behavior*, *4*, 107–111.

Grown–ups are turning to teen books. (2005, September 10). The Gainesville Sun, p. 3D.

Hoosain, R. (1973). The processing of negation. *Journal of Verbal Learning and Verbal Behavior*, *12*, 618–626.

Johnson-Laird, P. N., & Tridgell, J. M. (1972). When negation is easier than affirmation. *Quarterly Journal of Experimental Psychology*, *24*, 87-91.

Just, M.A., & Carpenter, P.A. (1971). Comprehension of negation with quantification. *Journal of Verbal Learning and Verbal Behavior*, *10*, 244–253.

Just, M.A., & Carpenter, P.A. (1992). A capacity theory of comprehension: Individual differences in working memory. *Psychological Review*, *99*, 122–149.

Kaup, B. (2001). Negation and its impact on the accessibility of text information. *Memory and Cognition*, *29*, 960–967.

Kaup, B., Dijkstra, K., & Ludtke, J. (2004). Resolving anaphors after reading negative sentences. Presented at the 44th annual meeting of the Psychonomic Society, Minneapolis, Minnesota.

Kaup, B., Ludtke, J., & Zwaan, R. A. (2005). Effects of negation, truth value, and delay on picture recognition after reading affirmative and negative sentences. Proceedings of the 27th annual conference of the Cognitive Science Society.

Kaup, B., & Zwaan, R.A. (2003). Effects of negation and situational presence on the accessibility of text information. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 439–446.

Kaup, B., Zwaan, R. A., & Ludtke, J. (2007). The experiential view of language comprehension: How is negation represented? In F. Schmalhofer & C. Perfetti (Eds.), *Higher level language processes in the brain: Inference and comprehension processes.* Mahwah, NJ: Erlbaum.

Kemper, S. (1987). Syntactic complexity and elderly adults' prose recall. *Experimental Aging Research*, *13*, 47–65.

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

Kintsch, W. (1998). *Comprehension: A paradigm for cognition.* New York: Cambridge University Press.

Light, L. L. (1988). Language and aging: Competence versus performance. In J.E. Birren & V.L. Bengston (Eds.), *Emergent theories of aging* (pp. 177–213). New York: Springer Publishing.

MacDonald, M. C., & Just, M. A. (1989). Changes in activation levels with negation. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 633–642.

Mehler, J. (1963). Some effects of grammatical transformations on the recall of English sentences. *Journal of Verbal Learning and Verbal Behavior*, *2*, 346–351.

Norman, S., Kemper, S., & Kynette, D. (1992). Adults' reading comprehension: Effects of syntactic complexity and working memory. *Journals of Gerontology: Psychological Sciences*, *47*, P258–P265.

Norman, S., Kemper, S., Kynette, D., Cheung, H., & Anagnopoulos, C. (1991). Syntactic complexity and adults' running memory span. *Journal of Geronotology: Psychological Sciences*, *46*, P346–P351.

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

Sherman, M. A. (1973). Bound to be easier? The negative prefix and sentence comprehension. *Journal of Verbal Learning and Verbal Behavior*, *12*, 76–84.

Sherman, M.A. (1976). Adjectival negation and the comprehension of multiply negative sentences. *Journal of Verbal Learning and Verbal Behavior*, *15*, 143-157.

Stine, E. A. L. (1990). On–line processing of written text by younger and older adults. Psychology and Aging, 5, 68–78.

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.

Stine–Morrow, E. A. L., Ryan, S., & Leonard, J. S. (2000). Age differences in on–line syntactic processing. *Experimental Aging Research*, *26*, 315–322.

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

Waters, G. S., & Caplan, D. (1996). Processing resource capacity and the comprehension of garden path sentences. *Memory & Cognition*, *24*, 342–355.

Waters, G. S., & Caplan, D. (2001). Age, working memory and on–line syntactic processing in sentence comprehension. *Psychology and Aging*, *16*, 128–144.

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

Author's Notes

This article is based on portions of Margolin's dissertation research. This research was supported by a Sigma-Xi Grant-in-Aid of Research awarded to Sara J. Margolin. This research was presented at the 12th Biennial Cognitive Aging Conference in April 2008.

We thank Ira Fischler, David Therriault, and M. Jeffrey Farrar for their insightful comments on this research. We also thank Jennifer Eastman, Max Thomas, Giovanna Morini, and Lindsey Bartlett for their assistance in stimuli development and data collection.

Correspondence concerning this article should be sent to Sara Margolin, who is now at The College Brockport, State University of New York, Department of Psychology, 350 New Campus Drive, Brockport, NY 14420. E-mail: smargoli@brockport.edu.

Table 1

Young and Older Adults' Demographic Characteristics

	Age Group			
	Young Adults		Older Adults	
	M	*SD*	*M*	*SD*
Years of Education*	13.1	1.3	16.8	2.7
Health rating (out of 10)	7.7	1.5	7.9	1.5
Vocabulary (out of 25)*	13.3	3.2	21.3	2.1
Hours spent writing*	2.6	1.5	1.2	0.8
Hours spent reading	3.1	1.9	2.8	1.4
Hours watching TV**	2.0	1.5	2.6	1.8
Hours doing crosswords**	0.2	0.5	0.5	1.0
Operation span*	0.9	0.1	0.8	0.1

*Note: * indicates that the age differences were significant at the $p < .01$ level; ** indicates that the age differences were marginally significant at the $p < .10$ level.*

Table 2

Means and standard errors of probe word naming times (msec)

Age Group	Sentence Type	Probe Type	*M*	*SE*
Young Adults	Negative	Verbatim	714.3	14.4
		Related	746.1	15.2
		New	761.8	14.5
	Non-negative	Verbatim	709.2	15.1
		Related	739.4	16.0
		New	758.7	16.4
Older Adults	Negative	Verbatim	775.5	21.9
		Related	798.7	21.7
		New	804.5	20.8
	Non-negative	Verbatim	762.6	19.9
		Related	796.1	21.3
		New	797.2	19.7

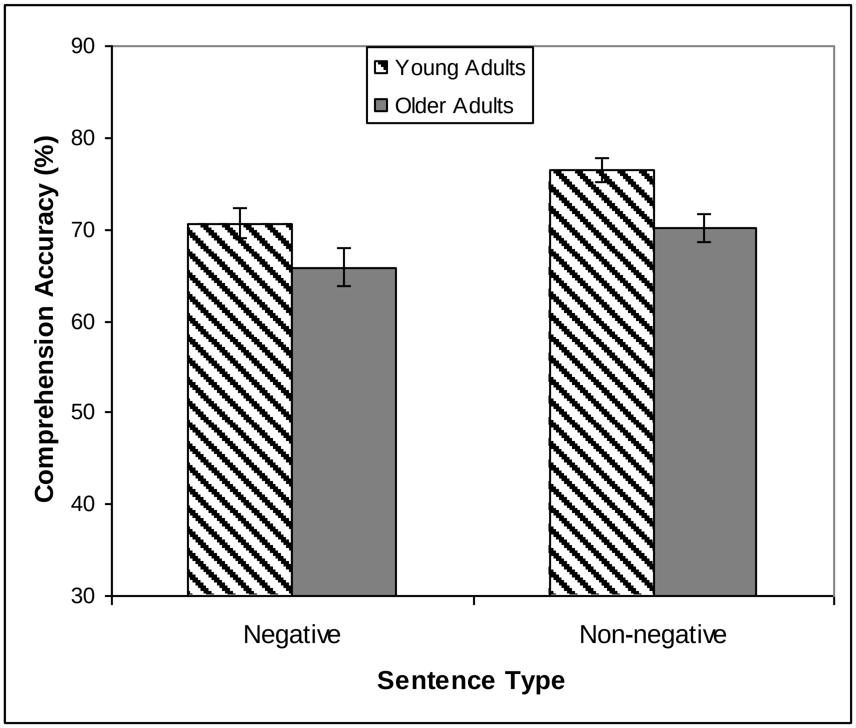
Table 3

Stepwise regression on comprehension accuracy of negative and non-negative sentences

Type of Sentence	Variable	β	*p*
Negative	Operation span	0.38	0.001
	Age	0.01	0.93
	Vocabulary	0.02	0.24
	Education	-0.14	0.13
	Time spent reading	-0.06	0.5
Non-negative	Operation span	0.42	0.001
	Age	-0.16	0.11
	Vocabulary	-0.14	0.14
	Education	-0.11	0.23
	Time spent reading	0.02	0.8

Figure Caption

Figure 1. Mean percent correct for comprehension questions as a function of age group and sentence type.


90
80
70
60
50
40
30
Comprehension Accuracy (%)
Young Adults
Older Adults
Negative
Non-negative
Sentence Type