NARRATIVE COMPREHENSION IN ALZHEIMER'S DISEASE: ASSESSING INFERNCES AND MEMORY OPERATIONS WITH A THINK-ALOUD PROCEDURE

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of SCOTT CREAMER find it satisfactory and recommend that it be accepted.

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Chair

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ASSESSING INFERNCES AND MEMORY OPERATIONS WITH A THINK-ALOUD PROCEDURE

Abstract

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To gain a better understanding of text comprehension abilities in Alzheimer's disease (AD), a think-aloud protocol was used to examine the role of inferencing and the memory operations used to produce inferences. Twenty participants with AD and 20 cognitively healthy older adults (OA) read narrative stories, one sentence at a time, pausing to talk aloud after each sentence. A verbal protocol analysis developed by Trabasso and Magliano (1996), was used to code the participants utterances into inferential and non-inferential clauses. We found that compared with OA controls, the AD participant's showed poorer story comprehension, produced fewer inferences, where less skilled at providing both explanations of story events and using prior text information to both explain and predict outcomes. In addition, the AD group relied more on the activation of world knowledge which led to less effective inferences. Furthermore, the AD participants produced more non-inferential statements particularly more that were incoherent. The findings suggest that the AD group's memory difficulties are interfering with their ability to create a global coherence to support text comprehension.

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CHAPTER ONE

INTRODUCTION

The ability to comprehend written words is important in our everyday lives as it allows us to interact within a social environment. For persons with Alzheimer's disease (AD), as comprehension for text becomes diminished they often begin to avoid reading, especially for leisure (Verghese et al. 2003), eliminating an important activity that helps maintain cognitive vitality. Difficulties with text comprehension can also cause significant problems with everyday activities, such as difficulty following health care prescriptions or other instructions. Although text comprehension deficits have been well documented in the AD literature (Grober & Bang 1995; Caramelli, Mansur, & Nitrini, 1996), it currently remains unclear whether the comprehension deficits of AD patients are due to memory impairments, aphasia/language disturbances, or executive function difficulties (Chapman et al., 2002; Kempler, Almor, & MacDonald, 1998a).

Although episodic memory loss is considered the primary symptom of AD, it has also been well documented that AD patients often experience deficits in language processing early in the disease course (Cummings, Benson, Hill, & Read, 1985). A recent comprehensive literature review on language performance in AD revealed that language deficits are seen in naming, verbal fluency, semantic knowledge, and discourse level processing (Taler & Phillips, 2007). Furthermore, reading comprehension generally declines with AD severity (Faust, Balota, Duchek, Gernsbacher, & Smith, 1997). However, the roles that grammatical difficulties, memory impairments, and breakdown of the semantic network, play in the decline in reading comprehension abilities in AD patients remains controversial.

To date, the majority of the AD text comprehension literature has focused on individual sentence level processing. Sentence comprehension is considered a multifactorial process consisting of grammatical relations, semantic elements, and cognitive components such as attention and working memory (see Grossman & White-Devine, 1998). Several studies have examined the roles of these various processes in the sentence comprehension abilities of individuals with AD (e.g., Bayles, 2003; Kempler, Almor, Tyler, Anderson, & MacDonald, 1998b). In one study, moderate AD patients showed no difficulties with reading comprehension of single words (as indicated by correct picture selection), but when reading sentences they demonstrated pronounced difficulties as the number of words increased (Bayles, 2003). These findings were attributed to difficulties resulting from an increased burden on working memory rather than to semantic deficits. A similar conclusion was reached by Kempler et al. (1998b), who showed that AD patients had greater difficulty with comprehension tasks that placed a high burden on working memory abilities (i.e., off-line as compared to online comprehension tasks; Caplan & Waters 1999). In a series of experiments, MacDonald and colleagues (MacDonald, Almor, Henderson, Kempler, & Anderson, 2001) further explored the assumption that comprehension impairments in AD stem from linguistic working memory deficits. MacDonald et al. concluded that linguistic knowledge, linguistic processing, and linguistic working memory are inextricably linked such that it is misleading to think of deficits in one domain causing comprehension impairments, whilst the other(s) remain intact. At the sentence level it seems clear that verbal working memory is implicated in comprehension deficits in AD, but the role of other cognitive and linguistic factors remains ambiguous.

Narratives, which represent larger more naturally occurring units of language, may be more revealing than smaller segments of language (Chapman et al., 2002) for the investigation of comprehension deficits in AD. Bayles and Kaszniak (1987) used a narrative comprehension task and found that patients with mild to moderate AD showed severe impairment when answering yes-no questions after listening to standardized paragraphs. More recently, Chapman et al. (2002) used narratives to assess both gist-level and detail level discourse processing in individuals with mild cognitive impairment (MCI) and AD. Participants followed along as they were read narratives, and were then given 5 minutes to review the text. Participants were next asked to summarize the narrative, and provide a main idea and lesson to be learned (gist-level comprehension). Recognition and recall were also tested for detail information not directly related to the gist of the story. The authors found that MCI and AD patients were equally impaired on gist level memory relative to controls. For detail-level processing, the AD patients were more impaired than the MCI group, who was more impaired than the control group. Consistent with findings from several other studies (Johnson, Storandt, & Boalota, 2003; Welland, Lubinski, & Higginbotham, 2002), Chapman and colleagues concluded that gist-level processing remains relatively intact in AD with detail processing showing more severe impairment as the disease progresses. Nevertheless, in a similar study Hudon et al. (2006) found gist-level and detail level memory to be equally impaired relative to age matched controls in both AD and MCI populations.

One important aspect of narrative comprehension, which has been widely studied in both normal and brain injured populations, but largely ignored in the AD literature, is the distinction between comprehending explicit versus implicit information. Although

LeDoux, Blum and Hirst (1983) found that severe AD patients had difficulty inferring correct pronoun referents, to our knowledge, only one study has directly evaluated the role of inferential comprehension in AD. In that study, patients with mild to moderate AD were read story passages while they followed along (Biassou, Onishi, Grossman, and D'Esposito, 1995). The participants retained a copy of the text as a reference while they responded to questions with answers that were either explicitly contained in the text or that required them to make inferences. Biassou and his colleagues found that the AD participants were impaired relative to controls on their comprehension of implicit, but not the explicit information.

In this study, we expand understanding of the roles that inferencing and memory play in the narrative comprehension deficits of individuals with AD by using a think-aloud protocol. Think-aloud protocols have been widely utilized in the cognitive literature to examine both inferential strategies used to comprehend text and memory operations employed to facilitate text comprehension (Cote & Goldman, 1999; Magliano, Trabasso, & Graesser, 1999). During the think-aloud procedure participants are periodically asked to verbalize their thoughts regarding the text at hand (Ericson & Simmon 1993). Several studies employing think-aloud methodology have provided data to support the assumption that thinking-aloud reveals a process of conscious attempts at understanding that occur during normal reading (Fletcher, 1986; Trabasso et al. 1996; Trabasso & Suh, 1993).

Prior research has identified two categories of reasoning processes that occur during reading comprehension: literal and inferential. Unlike literal strategies, inferential processing has been identified as an essential component to understanding text. This is because inferences allow readers to form causal links that go beyond information presented in the text and aid in forming a coherent mental representation of the text (Langston, Trabasso, & Magliano, 1999). To adequately create causal connections between different sections of text, however, readers must have access to previous information within the text. Therefore, memory operations are needed during reading to supply information to the reader that is necessary for forming inferences. Readers can explain incoming story events and actions by looking for causal antecedents of these events in either (a) working memory; (b) the prior text (or long-term memory), or (c) world knowledge.

Trabasso and Maglinano (1996) developed a think-aloud protocol analysis that distinguishes between types of inferences and the memory sources for the inferences. *Explanations* are inferences that serve to answer why questions providing details designed to give reasons for the state, event, or actions that occurred in the focal sentence. Research has consistently shown that skilled readers produce significantly more explanatory inferences than less skilled readers (Laing & Kamhi, 2002). *Predictive* inferences occur when readers anticipate future events and provide causal consequences of the event in the focal sentence. Predictions require the participants to provide information that has not yet occurred, thus, they are forward oriented. *Associations* are inferences that provide further clarification of the focal sentence. Associations usually serve to answer who, what, when, and where questions directly related to the focal sentence. It has been shown that less skilled readers make a significantly greater proportion of associative inferences compared to their more skilled counterparts (Whitney, Ritchie, & Clark 1991). In addition, the Trabasso and Magliano (1996) protocol analysis assigns one of three possible memory strategies to the inferences generated: *retrieval* (long-term memory), *maintenance* (short-term memory), and *activation* (world knowledge).

Despite the fact that studies have consistently shown that skilled readers generate more inferences than less skilled readers (Zwan & Brown, 1996; Long, Oppy, & Seely, 1994), to date, there has been little research directly examining inference production in individuals with AD. Research has also demonstrated that both short-term memory and long-term memory are important in making explanatory inferences, which have proved to be the best predictor of long term retention of story information (Trabasso & Suh, 1993). Therefore, it is logical to infer that the memory difficulties of individuals with AD could negatively impact text comprehension by limiting the ability of readers to make explanatory inferences. In the current study, individuals with AD and healthy older adult (OA) controls read narratives, one sentence at a time, pausing after each sentence to verbalize any thoughts that would help them understand the sentence within the context of the story. The protocols were scored for inference type (explanations, predictions, and associations) and the memory source (retrieval, maintenance, and activation). In comparison to cognitively healthy OA controls, individuals with AD were expected to produce fewer inferential statements and exhibit poorer comprehension for the text. If memory plays an important role in the reading comprehension deficits in AD, then the AD group should also produce fewer explanatory types of inferences which are important for retention of story information, and rely less on *retrieval* when making these explanatory inferences.

CHAPTER TWO

METHOD

Participants

Participants were 20 individuals with Alzheimer's disease (10 female, 10 male) and 20 healthy OA controls (10 female, 10 male) matched in age (t = -.22, p = .83) and education (t = .77, p = .45). Descriptive data is presented in Table 1. This study was conducted as part of a larger study that investigated memory and everyday abilities in older age (see Schmitter-Edgecombe et al., in press). Exclusionary criteria included a history of head trauma with permanent brain lesion, current or recent (past year) psychoactive substance abuse, history of cerebrovascular accidents, or known medical, neurological or psychiatric causes of cognitive dysfunction (e.g., epilepsy, schizophrenia, lewy body dementia). Participants were initially screened by phone, which included (a) a medical interview to rule out exclusion criteria (b) the Telephone Interview of Cognitive Status (TICS) to exclude participants who were significantly cognitively impaired; and (c) the Clinical Dementia Rating (CDR) instrument to assess dementia staging (Hughes, Berg, Danzinger, Cohen & Martin, 1982; Morris, 1993; Morris, McKeel, & Storandt, 1991). When available, collateral medical information, including the results of laboratory and brain imaging studies, were obtained and reviewed. Case consensus was used to establish diagnosis. The AD participants all met exclusion criteria had an MMSE score of 15 or greater met diagnosis consistent with criteria from the National Institute of Neurological and Communicative Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) (Mckhann et al., 1984 and Tierney et al., 1988). All of the control participants met exclusion criteria, reported no history of cognitive complaints, had a CDR score of 0, and an MMSE score of at least 26.

A battery of neuropsychological tests was administered to all participants. As can be seen in Table 1, the AD participants performed more poorly than their healthy OA controls on all tests, including attention and speeded processing (SDMT oral and written subtests; Trail Making Test, Part A), verbal learning and delayed memory (RAVLT total, immediate delay recall, and long delay recall), executive functioning (Trail Making test, Part B; Design Fluency), verbal fluency (COWAT, FAS total correct), and confrontation naming (BNT). All participants received a report documenting their performances. This protocol was approved by the Institutional Review Board at Washington State University.

Materials

Participants were presented with two narratives similar to those used by Schmitter-Edgecombe and Bales (2005), except that some of the wording was altered to elicit a greater number of inferential statements. Each narrative contained 20 sentences typed separately in the center of $4\frac{1}{4}$ x $5\frac{1}{2}$ inch cards. Both narratives were short stories about a character during a holiday. The first story was about a young girl named Cathy who wants a bike for Christmas. The second story was about a man named Dan who is driving home for Thanksgiving. To test for comprehension, 10 true/false questions were developed for each story. Five of the questions were based on factual information that was explicitly stated in the text, while the other five questions were inferential in nature, and required participants to rely on implicit information.

Procedures

Each participant completed two, 2-3 hour batteries of experimental and neuropsychological tasks that assessed learning and memory abilities, language ability, speeded processing, and executive functioning. The think-aloud procedure was the last test administered during the first day of testing. Participants were presented with one card at a time, and asked to read the sentence aloud, before verbalizing any thoughts they had regarding the story. The participants were instructed to focus on thoughts that would help them to understand the sentence within the context of the story. By stopping participants after they read each sentence as opposed to a large unit of text, we can be more certain that their responses accurately reflected the contents of their short-term memory (Fonteyn, Kuipers, & Grobe, 1993; Pressley & Afflerback, 1995). More specifically, based on procedures used by Trabasso & Suh (1993) and Schmitter-Edgecombe & Bales (2005) participants were instructed to:

> Report any thoughts that come readily to mind. There are no “right or “wrong” thoughts, but I would like you to concentrate on thoughts that help you understand the sentence in the context of the story. For example, you might discuss what you think is happening and report any inferences, predictions, or connections that you make between current story events and prior story events. In addition, it is important that you understand each story because you will later be asked to answer true/false question about each story.

Participants began by completing a practice story, “Ivan,” from Trabasso and Magliano (1996), prior to receiving the two experimental stories. Data indicates that thinking aloud is a natural process that does not require lengthy training (Ericsson &

Simon, 1993). Each participant's verbal responses were recorded and later transcribed verbatim for analysis. Story comprehension was evaluated by totaling the number of correct answers from the true/false questions. The number of correct factual and inferential questions was also analyzed separately in order to more specifically assess the type of comprehension difficulties participants are experiencing.

Think-aloud Scoring

To analyze the protocols in terms of types of inferences and the memory operations used to make them, protocols were broken down into clauses. A clause was defined as a subject, its verb and any extraneous modifiers. A change in subject or verb that clearly indicated a new thought by the participant was separated into a new clause. Each clause was assigned to one of four non-inferential or three inferential categories. The non-inferential statements were coded as: repetitions, paraphrases, incomplete, or meta-comments. A *repetition* was assigned when a participant directly reproduced the focal sentence. A *paraphrase* occurred if the clause was a restatement of the focal sentence that maintained its meaning. An *incomplete* represented incoherent thoughts or utterances that did not form logical ideas that were congruent with the story.[1] A *metacomment* occurred when a clause provided the participants feelings, opinions, or own experiences and was not dependent upon the information contained within the story (Zwaan & Brown, 1996).

The inferential statements were classified according to the criteria used by Trabasso and Magliano (1996). An *explanation* was assigned if the clause answers a why question that the focal sentence (the current sentence being read by the participant) implicitly produced. A *prediction* occurred when a participant's clause anticipated future events based upon information provided within the focal sentence. An *association* was assigned when a clause provides further clarification of the focal sentence in an attempt to answer a who, when, what, or where question.

Inferential statements were also evaluated for their accuracy by being judged as either correct or incorrect. Inferences that were logical and could be linked to the information in the story were coded as correct. Incorrect inferences were clauses that were illogical or unreasonable within the context of the story (Laing & Kamhi, 2002). In addition, any predictive inference that was later explicitly unsubstantiated by the preceding text was coded as incorrect.

Inferential statements were further coded for the memory operation that was used in its generation, based on the criteria outlined by Trabasso & Magliano (1996). Specifically, each inference was categorized as involving one of three memory operations: activation, retrieval, or maintenance. Table 2 shows an example text along with the think-aloud clauses and accompanying inferences and memory operations classifications. Activation of relevant world knowledge was considered a concurrent memory operation as it relied purely upon information contained within the focal sentence. *Maintenance* and *retrieval* were considered backward memory operations since prior information from the text was required to formulate the inferences. Any inference generated that included information provided earlier in the narrative was identified as relying upon maintenance or retrieval. *Maintenance* is thought to be dependent upon working memory and uses information that was from the sentence directly before the focal sentence. *Retrieval* is dependent upon long-term memory and draws on information that is more than one sentence prior to the focal sentence. *Activation* was assigned as the memory source when participants produced an inferential statement in which the information provided by the participant relies upon knowledge not given by the text. Consistent with the scoring criteria used by Trabasso and Magliano (1996), any information contained within the participant's response that was unnecessary for the formation of the inference, or that could be assumed based purely upon the setting of the narrative will not be considered to rely on retrieval or maintenance, but upon activation.

Scoring reliability

Two raters scored half of the data independently of one another. One rater was blind to the grouping of each individual. The raters agreed 96.2% for was whether the clause was inferential or non-inferential, on 88.7% of the specific type of inference (explanation, prediction, or association), and 91.6% of the type of memory source used in the formation of the inference (retrieval, maintenance, or activation). After the reliability check the two scorers reviewed the protocols together and resolved all discrepancies. The first author subsequently scored the remaining 50% of the un-scored protocols individually. These protocols were double checked by an independent rater, and all discrepancies were resolved.

CHAPTER THREE

RESULTS

Clauses

For all analyses, the data from both stories was combined as the pattern of data was similar for each story and story did not interact with group in any of the analyses. An independent samples *t*-test was first conducted to compare the total number of words produced about the stories. The analyses revealed no significant differences in total words produced by the AD group (*M* = 607; *SD* = 352; range = 174 - 1523) and the OA controls (*M* = 630; SD = 580; range = 225 - 2420), $t(38) = .15$, $p = .88$. A *t*- test analysis also revealed no difference in the overall number of coded clauses generated by the AD (*M* = 77; *SD* = 30; range = 40 - 146) and OA (*M* = 75; *SD* = 48; range = 40 - 209) groups, $t(38) = .19$, $p = .84$. These findings indicate that the AD participants were able to report their thoughts regarding the stories in a quantity comparable to the OA controls.

Consistent with the range of total clauses produced by participants in both the AD and OA control group, past research with the think-aloud method has revealed large individual variability in number of clauses (e.g., Schmitter-Edgecombe & Bales, 2005; Murray & Burke, 2003). To account for this individual variability, similar to Schmitter-Edgecombe & Bales (2005), we used proportional scores for several of the analyses as this allowed for interpretation of the data in terms of the proportion of the protocol that involved use of a specific strategy.[2] Table 2 shows a summary of the means and standard deviations for the verbal protocol data of both groups.

Before comparing the AD and OA control groups to determine whether there were differences in the number of inferences produced, the inferential and non-inferential statements were divided by the total number of clauses each participant produced. A 2 group (OA, AD) by 2 clause type (inferential, non-inferential) mixed model analysis of variance (ANOVA) with repeated measures on the second factor was then conducted. The analysis revealed that participants produced a greater proportion of inferential statements ($M = .71$) as compared to non-inferential statements ($M = .29$), Wilk's $\Lambda = .28$, $F(1,38) = 97.09$, $p < .001$, $\eta_p^2 = .72$. There was also a significant group by clause type interaction, Wilk's $\Lambda = .87$, $F(1,38) = 5.38$, $p < .05$, $\eta_p^2 = .12$. Breakdown of the interaction revealed that the OA group produced a greater proportion of inferential clauses ($M = .75$) and fewer non-inferential clauses ($M = .25$) than the AD group (inferential: $M = .66$; non-inferential: $M = .34$), $t(38) = 2.32$, $ps < .05$. These findings indicate that although both groups produced a significantly greater proportion of inferential compared to non-inferential clauses, the verbalization of the AD group contained a lower percentage of inferential statements (see Table 2).

Non-inferential clauses

To examine the usage of non-inferential statements by participants, 4 separate t-tests were run. To control for type-1 family wise errors, we used a Bonferoni adjustment resulting in an α-level of $p = .01$. We obtained proportional data by dividing each non-inferential statement type (meta-comments, paraphrases, repetitions, and incompletes) by the total number of clauses produced by each participant. The AD participant's ($M = .08$, $SD = .06$) produced significantly more incompletes compared to the OA group ($M = .03$, $SD = .03$), $t(39) = -3.20$, $p < .005$. The groups did not differ significantly in production of meta-comments (AD: $M = .22$, $SD = .12$, OA: $M = .18$, $SD = .13$), paraphrases (AD: $M = .02$, $SD = .02$, OA: $M = .02$, $SD = .04$), or repetitions (AD: $M = .02$, $SD = .03$ OA: $M =$

.01, *SD* = .02), *ts* < -1.16, *ps* > .26. These findings indicate that, in comparison to the OA group, the AD group produced more non-inferential statements that did not make sense within the context of the story or were incomprehensible.

Inference Type

Before examining the types of inferences produced by each group, the number of explanatory, associative, and predictive inferences were divided by the total number of inferences that each participant produced. A 2 group (AD, OA) by 3 inference type (explanation, prediction, and association) ANOVA revealed a significant main effect of inference type, Wilk's Λ = .71, $F(2, 37) = 7.46$, $p < .005$, $\eta_p^2 = .29$, which was modified by a significant group by inference type interaction, Wilk's Λ = .65, $F(2, 37) = 9.92$, $p < .001$, $\eta_p^2 = .35$. Breakdown of the interaction revealed that the OA group produced a greater proportion of explanatory inferences (*M* = .46) compared to predictive (*M* = .32), $t(19) = 4.37$, $p < .001$, and associative (*M* = .22) inferences, $t(19) = 3.57$, $p < .005$. In contrast, the AD participants generated proportionately more associative inferences (*M* = .40) compared to explanatory (*M* = .32), $t(19) = -2.55$, $p < .02$ and predictive (*M* = .28) inferences, $t(19) = -2.69$, $p < .02$. The proportion of explanatory inferences produced by the OA group (*M* = .46) was also significantly greater than that produced by the AD group (*M* = .32), $t(38) = 4.06$, $p < .001$, while the proportion of associative inferences was smaller (*M* = .32) relative to the AD group (*M* = .40), $t(38) = -2.53$, $p < .02$. (see Table 2). These findings indicate that with regard to inference production, the OA controls produced a greater proportion of explanatory inferences while the AD group was more apt to produce associative inferences.

The number of incorrect inferential statements made by each group was also examined. Because previous research has shown that incorrect inferential statements are relatively rare (e.g., Schmitter-Edgecombe & Bales, 2005), a high number of incorrect inferential statements would indicate poor story comprehension. Overall, less than 1% of the total inferential statements for both groups consisted of incorrect inferences. This indicates that both groups showed very accurate inference generation as they verbalized their thoughts following each story sentence.

Memory Source Type

To examine memory source types used by participants in the production of inferences, I examined each inference type separately. Since all three memory types can be used in the production of explanations and predictions, memory source was examined only for these two inference types. Associative inferences were not analyzed because our data indicate that associative inferences are primarily dependent upon one type of memory source, activation (see also Trabasso & Magliano, 1996a & Schmitter-Edgecombe and Bales, 2005). Proportional data was obtained by dividing the number of explanatory or predictive retrievals, maintenances, and activations by the total number of explanatory or predictive inferences, respectively, that each individual produced.

A 2 group (AD, OA) by 3 explanations memory source (retrieval, maintenance, activation) ANOVA revealed a significant main effect for source type, Wilk's $\Lambda = .29$ $F(2, 37) = 45.59$, $p < 001$, $\eta_p^2 = .71$. Participants produced a statistically greater proportion of explanations that relied upon activation ($M = .57$), than explanations that relied upon retrieval ($M = .23$), $t(39) = -8.69$, $p < .001$, or maintenance ($M = .19$), $t(39) = -8.68$, $p < .001$. There was also a significant group by source type interaction, Wilk's $\Lambda =$

.82, $F(2, 37) = 4.14$, $p < .05$, $\eta_p^2 = .18$. As can be seen in Table 2, the AD group ($M = .19$) produced significantly fewer explanations relying on retrieval compared with the OA controls ($M = .28$), $t(38) = 2.84$ $p < .01$. The AD group's ($M = .61$) heavier reliance compared to the OA group ($M = .53$) on activation as a memory source for explanatory inferences approached significance, $t(38) = -1.83$, $p = .075$. Examination of the individual data of participant's revealed that the proportion of explanatory inferences that relied on retrieval was greater than 20% for 17 of the control participants but for only 6 of the AD participants. These findings indicate that both groups relied most heavily upon activation of relevant world knowledge when formulating explanatory inferences. However, in producing explanatory inferences, the AD participants relied significantly less than controls upon information about the text that had been stored in long-term memory.

A second 2 (group) by 3 (predictions source type) ANOVA was run to examine memory sources used for predictive inference production. The ANOVA revealed a significant main effect of source type, Wilk's $\Lambda = .87$ $F(2, 37) = 181.47$, $p < .001$, $\eta_p^2 =$ .90. Participants produced a statistically greater proportion of predications that relied upon activation ($M = .80$), than predictions that relied upon retrieval ($M = .12$), $t(39) = -15.07$, $p < .001$, or maintenance ($M = .08$), $t(39) = -19.48$, $p < .001$. There was not a significant group by source type interaction, $F(2, 76) = 1.79$, $p > .05$; however, the difference between the OA controls ($M = .16$) and AD group ($M = .08$) in the proportion of predictions utilizing retrieval as a memory source approached significance, $t(38) = -19.48$, $p < .08$.These findings indicate that, similar to explanatory inferences, when generating predictive inferences both groups relied more heavily upon activation of relevant real world knowledge than upon long-term memory for the text or working memory. In addition, the AD group tended to rely on information stored in long-term memory less often than the control group when generating predictive inferences.

Comprehension Questions

Because the 20 true/false comprehension questions were divided into 10 inferential and 10 non-inferential questions, a 2 group (AD, OA) by 2 question type (inferential, non-inferential) ANOVA was conducted to compare comprehension performance. There was a significant main effect for question type, Wilk's $\Lambda = .69$, $F(1, 38) = 16.79$, $p < .001$, $\eta_p^2 = .90$, with more factual ($M = 7.6$) than inferential ($M = 6.5$) questions answered correctly. A group main effect revealed that the AD participants ($M = 11.9$) answered fewer of the comprehension questions correctly than the OA controls ($M = 16.3$), $F(38) = 40.42$, $p < .001$. Because no significant interaction between group and question type emerged, $F(1, 38) = .04$, $p > .05$, I collapsed across question type for all remaining analyses. These findings show that while both groups demonstrated more difficulty with the inferential questions, overall the AD participants demonstrated poorer performance on the comprehension questions compared to the OA controls.

Correlations for think-aloud method

Since narrative comprehension has been shown to be highly related to inference production, specifically explanatory inference production, a correlational analysis was conducted between comprehension (total accuracy on the factual and inferential questions), and the proportion of inferences and both the proportion of explanatory inferences and the proportion of explanatory inferences using retrieval as a memory source. For the AD group, the correlation between production of explanations that relied on retrieval and performance on the comprehension questions approached significance, *r*

= .42, p = .069. In contrast, the AD group's performance on the comprehension questions was not significantly related to the proportion of inferences r = .03, p = .91, or the proportion of explanatory inferences r = -.08, p = .75. The OA participant's performance on the comprehension questions was not significantly correlated with either the proportion of inferences, r = .06, p = .80, the proportion of explanatory inferences, r = .36, p = .12, or the proportion of explanations with retrieval, r = .09, p = .70. These finding are suggestive of a relationship between the AD group's performance on the comprehension questions and their ability to incorporate prior story events when making explanatory inferences.

Correlations with Neuropsychological Tests

To better understand cognitive factors that may be contributing to the AD groups comprehension difficulties, I conducted correlational analyses between participants think-aloud data and their performance on standard neuropsychological measures. More specifically, for each group we examined the relationship between the previously identified variables that differed between the AD and the OA groups (i.e. the proportion of inferences, the proportion of both explanatory and associative inferences, the proportion of explanatory inferences that rely on retrieval, the number of comprehension questions answered correctly, and the number of incompletes) and the neuropsychological measures of, attention and speeded processing, working memory, verbal memory, language, and executive functioning (see Table 1). Due to the large number of correlations a more conservative α level of $p \leq .01$ was used to control for type-I family wise errors.

For the OA controls, a significant negative correlation was found between the proportion of explanations relying on retrieval and one of the executive functioning tests, i.e., time on Trails B, $r = -.54$, $p = .01$. None of the remaining correlations reached significance, $rs < .44$. For the AD group, both comprehension question accuracy and the proportion of explanatory inferences relying on retrieval were significantly correlated with RAVLT short delayed recall, $rs > .54$, $p = .01$, and long delayed recall $rs > .53$, $p = .01$. The AD group's performance on the comprehension questions was also significantly correlated with Design Fluency, $r > .62$, $p < .01$, the 7/24 short delayed recall, $r > .67$, $p = .001$, and approached significance for the 7/24 long delayed recall, $r > .47$, $p = .045$. The number of incompletes (a non-inferential statement that is not able to be coded, or is nonsensical) uttered by the AD group significantly correlated with scores on the following neuropsychological measures: Shipley (a vocabulary test), $r > -.66$, $p < .005$, time on Trails A, $r > .74$, $p < .005$, Letter Number Sequencing, $r > .64$, $p < .005$, and DKEFS Letter Fluency, $r > -.65$, $p < .005$. None of the remaining correlations reached significance, $rs < .41$. Overall, these findings indicate that the AD participants who performed better on both short and long delayed recall tests for verbal and visual information also answered more of the comprehension questions correctly. A relationship also emerged between the AD participants overall cognitive status and their production of incomplete statements. In addition, explanatory inferences that relied on retrieval showed a relationship with verbal memory measures for the AD group, but executive functioning tests for the OA controls.

CHAPTER FOUR

DISCUSSION

This study used a think-aloud method to investigate the production of inferences and to assess what information (from the prior text and world knowledge) is consciously available in working memory during narrative comprehension in an AD population. AD patients and OA controls produced verbal reports of any thoughts that came to mind after reading each sentence of story narratives. I found that both groups produced comparable amounts of data (i.e., total number of words and clauses) on the think-aloud task. This indicates that the AD participants were adequately engaged in the task and suggests that think-aloud methodology is an appropriate tool to examine inference production in this population. The findings also revealed that the AD group had poorer comprehension for the narratives. The roles that memory impairment, poorer inferential strategies, and global cognitive deficits may play in the AD group's impaired comprehension are considered below.

Consistent with previous think-aloud studies (Trabasso & Magliano, 1996a, 1996b; Trabasso & Suh, 1993, Schmitter-Edgecombe & Bales, 2005; McGinnis, Goss, Tessmer, & Zelinski, 2008), when compared to non-inferential statements, inferences dominated narrative comprehension for both the OA controls and the AD group. Despite the dominance of inferential statements in the protocols of the AD group, they produced proportionally fewer inferences and more non-inferential statements than controls. Unlike inferential clauses which allow readers to make causal connections that go beyond information presented in the text, non-inferential clause types have been considered characteristic of incomplete comprehension and reduced textual cohesion (Maglinano et al., 1999, Trabasso & Magliano, 1996a, 1996b; Trabasso & Suh, 1993). Non-inferential clauses cannot only derail the textual cohesion process, but also result in the inclusion of irrelevant information. Consistent with this notion, compared to controls, I found that the AD group produced significantly more incompletes, a type of non-inferential clause that represents incoherent or illogical thoughts. Similarly, other studies have found that when producing story narratives AD patients give more empty words (Hier, Hagenlocker, & Schindler, 1985), more fragmented ideas and disruptive responses (Chapman et al., 1995), and more intrusions that disrupt story coherence (Ulatowska et al., 1988) than controls.

Previous research involving inferences has consistently shown explanatory inferences to be crucial in the comprehension of text as well as the primary means by which coherence in understanding is achieved (Anderson, 1976; Graesser, Bertus, & Magliano, 1995; Graesser et al., 1994; Hilton & Slugoski, 1986; Thagard, 1989; Schank, 1986). In comparison to the OA control group, I found that the AD group produced fewer explanatory inferences. Prior research has shown that less skilled readers also generate significantly fewer explanatory inferences than skilled readers (Laing & Kamhi, 2002; Trabasso & Magliano 1996a). The causal connections that are established through the formation of explanatory inferences are thought to both facilitate the integration of individual elements within the text-based memory representation and to enhance subsequent recall by providing retrieval pathways to these elements (Myers & Duffy, 1990). In other words the production of explanatory inferences provides greater opportunities (compared with predictive or associative inferences) for the reader to integrate prior information from the text into the current story events.

Also consistent with the idea that the AD group experienced greater difficulty than the OA group focusing on global, full text, coherence, is the finding that the AD participants produced more associative inferences. Though a type of inference, associations do not suggest the same coherent casual connections as explanations (Graesser & Clark, 1985; Graesser, Singer, Trabasso, 1994). Rather, associative inferences tend to be based on knowledge activated via semantic relations by individual words in the focal sentence. For example, Magliano and Millis (2003) found that, in comparison to skilled readers, when less skilled readers encountered a sentence that had a perceived low fit to the narrative, they talked more about the focal sentence than about how the sentence was casually related to the prior text. Because associative inferences are usually concurrent with story events they are also less likely to necessitate the retrieval of information from prior text or the maintenance of information from the previous sentence. The AD group's relatively higher production of associative rather than explanatory inferences may therefore reflect their memory deficits. More specifically, the AD group's difficulties retaining earlier text may have limited their ability to integrate the focal sentence within the larger discourse context and thereby resulted in the production of more non-inferential clauses and associative inferences and fewer explanatory inferences, when compared to controls.

Consistent with the notion that memory impairment is interfering with the AD group's ability to create global coherence through the use of inferences, I found that the AD group produced significantly fewer explanatory inferences relying on retrievals than controls. A trend was also found for the AD participants to produce fewer predictive inferences relying on retrieval compared with the OA control group. This likely reflects the AD participant's difficulties accessing and integrating information from the text stored in long-term memory, leading to inference generation not directly related to prior story events and poorer comprehension. According to Trabasso and Magliano's (1996a) verbal protocol analysis, retrieval as the memory source for inferences is thought to be an indication of long-term memory activity. Consistent with this, the AD group's production of explanatory inferences that relied on retrieval was related to their comprehension accuracy. Moreover, the finding that the AD participant's with the most impaired learning and memory measures also produced fewer explanations utilizing retrievals and demonstrated poorer comprehension, provides further support for the idea that the AD groups impaired episodic memory is significantly contributing to their difficulties comprehending text.

Whitney et al. (1991) suggested that less skilled reader's tendency to focus more on local, sentence by sentence coherence as opposed to global, full text, coherence was due to their inability to maintain information in working memory. Moreover, Trabasso and Magliano (1996b) explained that by maintaining information in working memory, it is possible to integrate text at greater distances without retrieving it from the long-term memory representation, which they point out, is an assumption of a number of models of discourse comprehension (e.g., Fletcher & Bloom, 1988; Kintsch & van Dijk, 1978; Mckoon & Ratcliff, 1992). The results from this study suggest that for populations that suffer from episodic memory impairment, memory difficulties may significantly influence a person's ability to maintain full text coherence. Nevertheless, despite the AD group performing significantly worse on a neuropsychological test of working memory, compared with the OA group, no differences were found between the groups on the usage of maintenance when making explanatory and associative inferences. However, it should be noted that qualitatively the AD participant's usage of maintenance as a memory source often reflected less sophisticated usages of maintenance. That is, when the AD group incorporated information from the prior sentence into their inferences, the information maintained was often not crucial to the formation of the inference, and therefore more likely to reflect rote recitation rather than conceptual integration.

It is possible that the working memory deficits of the AD group also partially contributed to their poorer comprehension. I may have failed to detect this using the Trabasso and Magliono (1996a) protocol analysis because of the definition of maintenance, which is thought to represent working memory. More specifically, the Trabasso and Magliano (1996a) protocol analysis defines maintenance as the incorporation of information into an inference that is from one sentence prior to the focal sentence. Whereas when information is incorporated from more than one sentence prior to the focal sentence, the inference's memory source is coded as retrieval. Within the working memory literature there is much controversy over working memory span in language processing (Van der Linden & Poncelet, 1998). It is possible that many of the coded retrievals contained information that is in relatively close proximity to the focal sentence, and therefore, may partially reflect a contribution from working memory. Moreover, the process of generating an explanatory inference that weaves in prior story events is likely, at least partially, to rely on aspects of working memory (e.g., long-term working memory; Ericsson & Kintsch, 1995). For example, when information is retrieved from long-term memory it must be reinstated into working memory in order for it to be integrated into the inference related to the focal sentence (Trabasso & Magliano, 1996a).

For that reason, it may be difficult to make conclusive statements regarding the role of working memory in comprehension based on data from this protocol. Nonetheless, it is unlikely that group differences in working memory can fully account for the AD participant's poorer narrative comprehension and tendency to focus more on local, sentence by sentence, coherence.

This study has several specific limitations that may limit the generalizability and reproducibility of the results. These limitations include the small sample size, which limited power for the between group comparisons. The study participants were also fairly highly educated, which could limit generalizability of the findings to populations with lower educational attainment. Despite these limitations this study points to some directions for future research. Previous research has shown older adult reader's to be less adept at processing narratives compared to their younger counterparts (Samuels & Eisenberg, 1981), but that older adults showed superior processing abilities when reading expository texts (Zelinski & Gilewki, 1988). Expository texts are a widely represented reading material frequently encountered by and relevant to older adults (e.g., health care information), therefore future reading comprehension research with healthy older adults and those with neurodegenerative disorders should include expository and/or procedural texts. Future think-aloud studies may also benefit from not only collecting data during the reading process but also during comprehension testing, especially on inferential questions. Gaining a clearer understanding of the comprehension strategies for those with more mild memory deficits (e.g., Mild Cognitive Impairment) is also important since this population will be most likely to benefit from interventions targeted at improving reading comprehension.

In conclusion we used a think-aloud protocol analysis developed by Trabasso and Magliano (1996a) and found that it could be used to reveal the content of information (from the prior text and world knowledge) available to working memory when reading narrative text in an AD population. We found that despite producing a similar amount of data as controls, the AD participant's produced fewer inferences, where less skilled at providing both explanations of story events and using prior text information to both explain and predict outcomes. In addition, the AD group relied more on the activation of world knowledge which led to more superficial inferences. Furthermore, the AD participants produced more overall non-inferential statements particularly more that were incoherent. These findings reflect the AD group's inability to create a global coherence to support comprehension. Moreover, it is likely that memory difficulties are the primary cognitive deficit interfering with the AD patients ability to integrate story events through the use of inferences. The results suggest that when presenting information to AD patients, care should be taken to state information explicitly. Similarly, when providing more detailed information, it is important to re-contextualize the information to reduce memory demands. This suggestion is supported by our finding that the AD group was able to successfully produce logical inferential statements based on the activation of world knowledge. Our findings also suggest that the development of text that reduces demands placed on memory and inference production may help facilitate text comprehension in individuals with memory impairments. Continued research in this area should increase our understanding of those factors that limit narrative comprehension abilities in AD patients thereby leading to the development of better remediation techniques for improving text comprehension.

REFERENCES

Anderson, J.R. (1976). Language memory and thought. Hillsdale, NJ: Erlbaum.

Bayles, K.A. (2003). Effects of working memory deficits on the communicative functioning of Alzheimer's dementia patients. Journal of Communication Disorders, 36(3), 209-19.

Bayles, K.A., & Kaszniak, A.W. (1987). Communication and cognition in normal aging and dementia. Boston, MA: College Hill/Little, Brown and Co.

Biassou, N., Onishi, K. Grossman, M. & D'Esposito, M. (1995) Text comprehension in Alzheimer's disease [Abstract]. Brain and Language, 51, 186-188.

Caplan, D., & Waters, G.S. (1999). Verbal working memory capacity and language comprehension. Behavioral and Brain Science, 22, 77-94.

Caramelli, P., Mansur, L.L., & Nitrini, R. (1996). Language and communication disorders in dementia of the Alzheimer type. In Stemmer, B., Whitaker, H.A., (Eds.), Handbook of Neurolinguistics. San Diego, CA: Academic Press.

Chapman, S.B., Ulatowska, H.K., King, K., Johnson, J., & McIntire, D.D., (1995). Discourse in early Alzheimer's disease versus normal advanced aging. American Journal of Speech-Language Pathology, 4, 125-129.

Chapman, S.B., Zientz, J., Weiner, M., Rosenberg, R., Frawley, W., & Burns, M.H. (2002). Discourse changes in early Alzheimer disease, mild cognitive impairment, and normal aging. Alzheimer Disease and Associated Disorders, 16(3), 177-186.

Cote, N., & Goldman, S.R., (1999). Building representations of information text: Evidence from children's think-aloud protocols. In H. van Oostendorp & S.R. Goldman (Eds.), The construction of mental representations during reading. (pp. 169-193). Mahwah, NJ: Erlbaum.

Cummings, J. L., Benson, D.F., Hill, M.A., & Read S. (1985). Aphasia in dementia of the Alzheimer type. Neurology, 35, 394-397.

Delis, D.C., Kaplan, E., & Kramer, J.H. (2001). Trail Making Test A & B. San Antonio, TX: The Psychological Corporation.

Ericsson, K.A., Kintsch, W. (1995). Long-term working memory. Psychological Review, 102(2), 211-245.

Ericsson, K.A., & Simon, H.A. (1993). Protocol Analysis: Verbal reports as data (Revised Eds.). Cambridge, MA: The MIT Press.

Faust, M.E., Balota, D.A., Duchek, J.M., Gernsbacher, M.A., & Smith, S. (1997). Inhibitory control during sentence comprehension in individuals with dementia of the Alzheimer type. Brain Lang, 57(2), 225-253.

Fletcher, C.R. (1986). Strategies for the allocation of short-term memory during comprehension. Journal of Memory and Language, 25, 43-58.

Fletcher, C.R. & Bloom, C.P. (1988). Causal reasoning in the comprehension of simple narrative texts. Journal of Memory and Language, 27, 235-244.

Fonteyn, M.E., Kuipers, B., & Grobe, S.J. (1993). A description of think aloud method and protocol analysis. Qualitative Health Research, 3, 430-441.

Gernsbacher, M.A., (1997). Group Differences in Suppression Skill. Neuropsychology and Cognition, 4, 175-184).

Graesser, A. C., Bertus, E. L., & Magliano, J. P. (1995). Inference generation during the comprehension of narrative text. In Lorch, R. & OÕBrien, E. (Eds.), Sources of coherence in text comprehension (pp. 295-320). Hillsdale, NJ: Erlbaum.

Graesser, A.C., & Clark, L.F. (1985). Structures and processes of implicit knowledge. Norwood, NJ: Ablex.

Graesser, A.C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. Psychological Review, 101, 371-395.

Grober, E., & Bang, S. (1995). Sentence comprehension in Alzheimer’s disease. Developmental Neuropsychology, 11, 95-107.

Grossman, M., & White-Devine, T. (1998). Sentence comprehension in Alzheimer's disease. Brain Lang, 62(2), 186-201.

Hier, D.B., Hagenlocker, K., & Schindler, AG (1985). Language disintegration in dementia: Effects of etiology and severity. Brain and Language, 25, 117–133.

Hilton, D.J. & Slugoski, B.R. (1986). Knowledge based causal attribution: The abnormal conditions focus model. Psychological Review, 93(1), 75-88.

Hudon, C., Belleville, S., Souchay, C., Gély-Nargeot, M.C., Chertkow, H., Gauthier, S. (2006). Memory for gist and detail information in Alzheimer's disease and mild cognitive impairment. Neuropsychology, 20(5), 566-577.

Johnson, D.K., Storandt, M., Balota, D.A. (2003). Discourse analysis of logical memory recall in normal aging and in dementia of the Alzheimer type. Neuropsychology, 17(1), 82-92.

Kempler, D., Almor, A., & MacDonald, M.C. (1998). Teasing apart the contribution of memory and language impairments in Alzheimer's disease: An online study of sentence comprehension. American Journal of Speech-Language Pathology, 7(1), 61-67.

Kempler, D., Almor, A., Tyler, L.K., Andersen, E.S., & MacDonald, M.C. (1998). Sentence comprehension deficits in Alzheimer's disease: a comparison of off-line vs. on-line sentence processing. Brain Lang, 64(3), 297-316.

Kintsch, W., & van Dijk, T.A. (1978). Toward a model of text comprehension and production. Psychological Review, 85(5), 363-394.

Laing, S.P., & Kamhi, A.G. (2002). The use of think-aloud to compare inferencing abilities in average and below-average readers. Journal of Learning Disabilities, 35, 436-447.

Langston, M.C., Trabasso, T., & Magliano, J.P. (1999). Modeling online comprehension. In A. Ram & K. Moorman (Eds.), Computational models of reading and understanding (pp. 181-226). Cambridge, MA: MIT Press.

LeDoux, J.E., Blum, C., & Hirst, W. (1983). Inferential processing of context: Studies of cognitively impaired subjects. Brain and Language, 19, 216-224.

Long, D., Oppy, B., & Seely, M. (1994). Individual differences in the time course of inferential processing. Journal of Experimental Psychology: Learning, Memory, and Cognition, 6, 1456-1470.

MacDonald, M.C., Almor, A., Henderson, V.W. Kempler D., & Anderson, E.S. (2001). Assessing working memory and language comprehension in Alzheimer's disease. Brain and Language, 78, 17-42.

Magliano, J.P., Millis, K.K., (2003). Assessing reading skill with a think-aloud procedure. Cognition and Instruction, 21, 251-283.

Magliano, J.P., Trabasso, T., & Graesser, A.C. (1999). Strategic processing during comprehension. Journal of Educational Psychology, 91, 615-629.

McGinnis, D., Goss, R.J., Tessmer, C., & Zelinski, E.M. (2008). Inference generation in young, young–old and old–old adults: Evidence for semantic architecture stability. Applied Cognitive Psychology, 22, 171–192.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E.M. (1984). Clinical diagnsosis of Alzheimer's disease: Report of the NINCDS-ADRDA workgroup under the auspices of the Department of Health and Human Services Task Force on Alzheimer's disease. Neurology, 34, 939-944.

Mckoon, G., & Ratcliff, R. (1992). Inference during reading. Psychological Review, 99(3), 440-466.

Myers, J.L., & Duffy, S.A. (1990). Causal inferences and text memory. In A.C. Graesser & G.H. Bower (Eds.), Inferences and text comprehension (pp. 159-173). Hillsdale, NJ: Lawrence Erlbaum.

Pressley, M., & Afflerback, P. (1995). Verbal protocols of reading: The nature of constructively responsive reading. Hillsdale, NJ: Erlbaum.

Samuels, S.J., Eisenberg, P. (1981). A framework for understanding the reading process. In F.J. Pizzolo & M.C. Wittrock (Eds), Neuropsychological and cognitive processes in Reading. New York: Academic Press.

Schank, R.C. (1986). Explanation patterns: understanding mechanically and creatively. Hillsdale, NJ: Erlbaum.

Schmitter-Edgecombe, M., & Bales, J.W. (2005). Understanding text after severe closed-head injury: Assessing inferences and memory operations with a think-aloud procedure. Brain and Language, 94, 331-346.

Smith, A. (1991). Symbol Digit Modalities Test. Los Angles: Western Psychological Services.

Taler, V., & Phillips, N.A. (2007). Event-related brain potential evidence for early effects of neighborhood density in word recognition. Neuroreport, 18 (18), 1957-1961.

Thagard, P. (1989). Explanatory coherence. Behavioral and Brain Sciences, 12, 435-467.

Tierney, M.C., Fisher, R.H., Lewis, A.J., Zorzitto, M.L., Snow, W.G., Reid, D.W., Nieuwstraten, P. (1988). The NINCDS-ADRDA Work Group criteria for the clinical diagnosis of probable Alzheimer's disease: a clinicopathologic study of 57 cases. Neurology, 38(3), 359-364.

Trabasso, T., Magliano, J.P., (1996a). Conscious understanding during comprehension. Discourse Processes, 2, 255-287.

Trabasso, T., Magliano, J.P., (1996b). How do children understand what they read and what ca new do to help them? In M. Graves, P. van den Brock, & B. Taylor (Eds.), The first R: Every child’s right to read. New York: Teacher’s College Press.

Tabasso, T., Secco, T., & van den Broek, P. (1984). Causal cohesion and story coherence. In H. Mandl. N.L. Stein, & T. Trabasso (Eds.), Learning and comprehension of text. Hillsdale, NJ: Erlbaum.

Trabasso, T., & Suh, S. (1993). Understanding text: Achieving explanatory coherence through on-line inferences and mental operations in working memory. Discourse Processes, 16, 3-34.

Trabasso, T., & van den Broek, P. (1985). Causal thinking an importance of story events. Journal of Memory and Language, 24, 612-630.

Ulatowska, H.K., Allard, L., Donnell, A., Bristow, J., Haynes, S.M., Flower, A., & North, A.J. (1988). Discourse Performance in Subjects with Dementia of the Alzheimer Type. In H.A. Whitaker (Ed.), Neuropsychological studies of nonfocal brain damage : Dementia and trauma. New York: Springer-Verlag.

Van der linden, M., & Poncelet. M. (1998). The role of working memory in language and communication disorders. In B. Stemmer & H.A. Whitaker (Eds.), The handbook of neurolinguistics. San Diego, CA: Academic Press.

Verghese, J, Lipton, R.B., Katz, M.J., Hall, C.B., Derby, C.A., Kuslansky, G., Ambrose, A.F., Sliwinski, M., & Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. New England Journal of Medicine. 348(25), 2508-2516.

Welland, R.J., Lubinski, R., Higginbotham, D.J. (2002). Discourse comprehension test performance of elders with dementia of the Alzheimer type. Journal of Speech, Language, and Hearing Research, 45(6), 1175-1187.

Wechsler, D. (1997). Letter-Number Sequencing. In Wechsler Adult Intelligence Scale-Third Edition. San Antonio, TX: The Psychological Corporation.

Whitney, P. (1997). Understanding and remembering discourse. In, The psychology of language. New York: Houghton Mifflin.

Whitney, P., Ritchie, B.G., & Clark, M.B. (1991). Working-memory capacity and the use of elaborative inferences in text comprehension. Discourse Processes, 14, 133-145.

Zelinski, E.M., & Gilewski, M.J. (1988) Memory for prose in aging: A meta-analysis. In M.L. Howe & C.J. Brainerd (Eds.), Cognitive development in adulthood. New York: Springer-Verlag.

Zwaan, R.A., & Brown, C.M. (1996). The influence of language proficiency and comprehension skill on situation-model construction. Discourse Processes, 21, 289-328.

Footnotes

[1] Incompletes are a category of non-inferential statement that we added to our protocol analysis after encountering a relatively high number of clauses that could not be coded based on the protocol criteria. More specifically, many of the protocols contained clauses that did not make sense in the context of the story often consisting of incomplete sentences or vague thoughts (e.g., focal sentence: "Suddenly he noticed a truck barreling down on him," participants response: "boy are truck drivers sure, a,a happy hello to me anyway," participants response: "get out of the….half of the truck."

[2] All analyses were also conducted using raw scores and revealed a pattern of data similar to that found using proportional scores.

Table 1.
Demographic data and mean summary data for the Alzheimer's disease (AD) and older adult (OA) control groups

	AD		Control	
Variable or test	Mean	SD	Mean	SD
Age (in years)	77.25	7.40	76.65	9.99
Education (in years)	14.45	3.08	15.20	3.09
MMSE	21.63[a]	4.89	27.85**	3.07
Attention & Speeded Processing				
SDMT total oral correct	31.93[b]	9.74	47.20**	14.11
SDMT total written correct	27.93[b]	9.76	38.88**	11.84
Trails A (seconds)	81.47[a]	42.56	45.05**	15.68
Working Memory				
WAIS-III letter/# sequencing	5.22[a]	3.04	9.30**	2.32
Verbal Memory				
RAVLT List Learning (1-5)	21.00	8.27	41.12**	8.97
RAVLT short-delay free recall	1.45[a]	2.23	7.31**	3.19
RAVLT long-delay free recall	1.15[a]	1.98	7.30**	2.75
Language				
BNT total correct	44.05[a]	12.41	55.25**	4.48
D-KEFS Category Fluency	21.33[a]	7.56	37.30**	7.85
D-KEFS Letter Fluency	22.72[a]	13.85	39.20**	13.95
Executive Functioning				
D-KEFS Design Fluency	8.84[a]	7.56	22.58**	7.07
Trails B (seconds)	221.53[b]	92.21	113.80**	51.38

Notes. Unless otherwise indicated, mean scores are raw scores. AD = Alzheimer's Disease; WAIS-III = Wechsler Adult Intelligence Scale-Third Edition; SDMT = Symbol Digit Modalities Test; RAVLT = Rey Auditory Verbal Learning Test; BNT = Boston Naming Test; D-KEFS = Delis-Kaplan Executive Functioning Scale.

[a] Data available for only 19 AD participants, as one of the AD participants was unable to complete the entire neuropsychological battery due to time constraints.

[b] data available for only 15 AD participant's as several were unable to complete the task because of its difficulty

* $p \leq .05$

** $p < .01$

Table 2.
Sample protocol and analysis.

Narrative "Cathy"	Participants	Inferences	Memory operations
Cathy's mother mentioned taking her to see Santa Clause.	C1. It must have been close to Christmas	Exp(C)	A
Cathy started counting the days until Christmas.	C2. Getting anxious,	Exp(C)	A
	C3. Marking them on a calendar.	Ass(C)	A
She didn't mind standing in line for an hour.	C4. Because she gets to see Santa	Exp(C)	R
An elf took her picture with Santa Claus.	C5. I'm assuming she sat on his lap.	Ass(C)	A
Cathy told Santa she wanted a bike for Christmas.	C6. She is young and still believes in Santa.	Exp(C)	A
She hoped for one with a pretty pink basket on the front.	C7. Because she figured it was one of these	Inc	NA
Cathy loved her sister's	C8.Well she must have had an older sister with a bike	Exp(C)	R
	C9 don't know how many sisters she had	Ass(C)	A
When Cathy got home that evening, she told her father about her trip.	C10. Father must have been working all day.	Exp(C)	A
When Christmas Eve finally arrived, Cathy knew she wouldn't be able to sleep.	C11. Too excited thinking about that bicycle.	Exp(C)	R
Her parents let her open one present.	C12. Well it wasn't a bike.	Pred(C)	M
It was a doll.	C13. She is probably disappointed.	Pred(C)	A
Cathy couldn't keep from feeling a little disappointed.	C14. I guess I guessed that one right,	Meta	
	C15. She still wanted the bicycle.	Exp(C)	R
It wore a beautiful blue dress.	C16. Blue is my granddaughter's favorite	Meta	
Cathy felt a little better.	C17. But she still wanted the bike.	Exp(C)	R
Afterwards, Cathy helped her parents get ready for a dinner party.	C18. That was very nice of her	Meta	NA
They had invited quite a lot of relatives over.	C19. They were now waiting.	Ass(C)	A
Cathy was anxious to see her grandparents.	C20. Must not see them too often.	Exp(C)	A

She thought they would get there first.	C21. Must be the ones that live the closest	Exp(C)	A
As soon as they arrived, they went over to talk to Cathy.	C22. Wanted to see what she wanted for Christmas.	Exp(C)	R
They asked her what she most wanted to get for Christmas.	C23. It was a bike that she wanted.	Exp(C)	R

<u>Narrative "Dan"</u>	<u>Participants</u>	<u>Inferences</u>	<u>Memory operations</u>
Dan had been driving all night in order to get home for Thanksgiving.	C1. He must be a college student.	Exp(C)	A
He was starting to fall asleep.	C2. Getting drowsy	PA	N/A
He decided to stop and get some coffee.	C3. He plans to keep on driving.	Exp(C)	R
He felt much better.	C4. The coffee helped him.	Exp(C)	M
Before long Dan drove past a van parked on the side of the road.	C5. He is going to stop and help them.	Pred(C)	A
It was stopped with a flat tire.	C6. He probably hoped they had a spare	Pred(C)	A
Its spare tire must have been underneath everything.	C7. Must have been a lot of things taken up in the van.	Exp(C)	R
Suitcases were strewn everywhere by the side of the road.	C8. To get to the tire I guess they had to unload it	Exp(C)	M
Soon the sun would start to come up.	C9. Must have been really late.	Ass(C)	A
Dan figured he had about 100 miles left to drive.	C10. Couple hours	Ass(C)	A
While he was driving his mind wandered.	C11. Probably thinking about thanksgiving	Pred(C)	R
He thought about how he had not had a home cooked meal in a couple of months.	C12. Must have ate in restaurants all the time.	Exp(C)	A
Suddenly, he noticed a truck barreling down upon him.	C13. He wondered where am I going to run to.	Pred(I)	A
Before he could react, it had run him off the road.	C14. Doesn't indicate whether it was into a ditch	Ass(C)	A
Unfortunately, Dan didn't get a chance to get the license plate number.	C15. He is just controlling his car.	Exp(C)	M
Dan was shaken but not hurt.	C16. I'm assuming the car wasn't either.	Exp(C)	M
He decided to continue his drive home.	C17. Didn't have far to go.	Exp(C)	A

After being back on the road awhile, he saw a diner and stopped to go inside.	C18. Probably looking for the trucker.	Exp(C)	R
A policeman came in and started a conversation with him.	C19. And he told the policeman about the trucker.	Pred(C)	M
He asked what type of vehicle he had seen when the people were changing their flat.	C20. I don't know why,	Meta	N/A
	C21. well I am curious why the policeman is asking what kind of vehicle it was,	Ass(C)	M
	C22. if he knew a vehicle was on the side of the road with a flat	PA	N/A
	C23. he should have known what the vehicle was.	Meta	N/A

Note. C1, C2, C3 = clause number; EX = explanation; PR = prediction; ASS = association; PA = paraphrase; Meta = Metacomment; Inc = incomplete; (C) = correct; (I) = incorrect; A = activation; M = maintenance; R = retrieval; N/A = not applicable.

Table 3.
Narrative comprehension data for the Alzheimer's disease (AD) and older adult (OA) groups

	AD		Control	
Variable	*M*	*SD*	*M*	*SD*
Total words	607	353	630	580
Total clauses	75	30	77	48
Clause type				
Proportion inferential	.66	.13	.75*	.14
Proportion non-inferential	.34	.13	.25*	.14
Inference type				
Proportion explanations	.32	.10	.46**	.12
Proportion predictions	.28	.13	.22	.15
Proportion associations	.40	.09	.32*	.11
Memory source type explanations				
Proportion retrieval	.19	.10	.28**	.10
Proportion maintenance	.20	.16	.19	.10
Proportion activation	.61	.15	.52	.16
Memory source type predictions				
Proportion retrieval	.08	.08	.15	.17
Proportion maintenance	.09	.09	.06	.11
Proportion activation	.83	.13	.77	.20
Comprehension				
Total inferential/Non-inferential True/false questions accuracy	11.9	2.49	16.3**	1.84

Notes. AD = Alzheimer's Disease. Proportional data represents the amount of each type divided by the total amount possible (i.e., proportion of inferences = number of inferences/total clauses).
* $p < .05$
** $p < .01$