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THE INFLUENCE OF TASK TYPE AND WORKING MEMORY ON THE SYNTACTIC COMPLEXITY OF NARRATIVE DISCOURSE PRODUCTION IN HEALTHY AGING ADULTS

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THESIS
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A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in the
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at the University of Kentucky

By

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Lexington, Kentucky

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2014

ABSTRACT OF THESIS

THE INFLUENCE OF TASK TYPE AND WORKING MEMORY
ON THE SYNTACTIC COMPLEXITY OF NARRATIVE DISCOURSE
PRODUCTION IN HEALTHY AGING ADULTS.

This study investigated the lifespan influences of task type and working memory on the syntactic complexity of narrative discourse production. Participants included 180 healthy adults across three age cohorts: 20-29 years (Young Group), 60-69 years (Older Group) and 75-89 years (Elderly Group). Participants completed standardized working memory measures and four discourse tasks (single/sequential picture description, storytelling and personal recount). Syntactic complexity for each sample was measured via clausal density yielding a complexity index. For analysis, participants were placed into one of two groups based on working memory scores above (High Working Memory Group) or below (Low Working Memory Group) the mean. Significant differences in syntactic complexity between working memory groups were found for the single picture description and the storytelling; individuals in the high working memory group produced language with greater syntactic complexity. When the effects of cohort and working memory were investigated with a two-way ANOVA, working memory group was no longer significantly related to syntactic complexity. However, there was a significant relationship between *cohort* and syntactic complexity for the single picture description and storytelling tasks. Analyses indicate that the relationships between syntactic complexity, age, and working memory are dependent on task type.

KEYWORDS: Syntactic Complexity, Working Memory, Narrative Discourse, Healthy Aging

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May _, 2014

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Chapter One: Introduction

Background

Discourse can be described as language beyond the boundaries of isolated sentences and is commonly referred to as the basic unit of social communication (Brownell & Joanette, 1993; Ulatowska & Olness, 2004). Of interest in the current study is narrative discourse production. Narrative discourse consists of a sequence of dependent events that develop over time and space and typically include a beginning and ending (Wright & Capilouto, 2009). Narrative discourse plays an important role in everyday conversational exchanges, as stories are often integrated throughout a conversation. However, as opposed to conversational discourse, wherein multiple speakers co-construct topics and comments, in narrative discourse the speaker independently conveys information to the listeners. Thus, narrative discourse is thought to elicit a more cognitively demanding language sample (Byrd, Logan, & Gillam, 2012).

Narrative discourse has become a well-established tool for obtaining language samples (Labov & Waletzky, 2003). In the field of speech and language pathology, clinicians collect narrative discourse samples from persons with acquired communication deficits as a means of examining connected speech reminiscent of everyday situations (Armstrong, 2000). The successful production of discourse requires the integration of cognitive and linguistic skills to organize units of information into a coherent and meaningful message (Shadden, 1997; Wright, 2011). Therefore, examination of discourse can not only reveal linguistic skills, but also can reflect elements of the underlying cognitive processes that support those skills (Wright, Capilouto, Srinivasan, & Fergadiotis, 2011).

Discourse analysis is regarded as a sensitive tool for detecting language impairments and can also be an effective tool for monitoring changes in linguistic functioning in healthy adults (de Lira, Ortiz, Campanha, Bertolucci, & Minett, 2011; Duong, Giroux, Tardif, & Ska, 2005). There are two types of discourse analyses, microlinguistic, which measures intra- phrasal (within-sentence) functions, and macrolinguistic, which measures inter-phrasal (between-sentence) functions. Microlinguistic processes are responsible for the creation of well-formed sentences (de Lira et al., 2011; Marini, Boewe, Caltagirone, & Carlomagno, 2005). The focus of the current study is microlinguistic processes, specifically syntactic complexity. Syntactic complexity is a specific microlinguistic measure of discourse production that describes the grammatical complexity of language. There are various methods to calculate syntactic complexity, but it is characteristically measured by counts of different types of dependent clauses and the number of dependent clauses per utterance (Burke & Shafto, 2008). The terms embedded clause, subordinate clause, and dependent clause are used synonymously across the literature on this subject.

The collection of discourse and subsequent syntactic analysis of the language sample is used to gain insight into the grammatical complexity of language of both healthy individuals as well as different groups of persons with neurological disease. For example, syntactic analysis has been employed to investigate the effects of healthy aging on the syntactic complexity of adult language in the context of narrative discourse (Cooper, 1990; Glosser & Deser, 1992; Kemper, Rash, Kynette, & Norman, 1990; Kynette & Kemper, 1986; Marini et al., 2005; Miller, 2001).With few exceptions

(Cooper, 1990; Glosser & Deser, 1992), research investigating the productive narrative discourse of older adults affirms a significant age-related decline in syntactic complexity.

The decline of productive syntactic complexity with healthy aging has been demonstrated using a variety of narrative discourse tasks, including picture description (Marini et al., 2005), the retelling or creation of a story (Kemper et al., 1990), and recounts of events (Kynette & Kemper, 1986; Miller, 2001). The type of stimuli employed to elicit narrative discourse has been shown to impact performance (Capilouto, Wright, & Wagovich, 2005; Marini et al., 2005; Nippold, Cramond, & Hayward-Mayhew, 2013). Thus, it is hypothesized that the age-related declines in syntactic complexity may vary depending on the method of narrative discourse elicitation and the amount of support or scaffolding a stimulus provides for the speaker; however, this hypothesis warrants further systematic investigation.

The influences on documented reductions of syntactic complexity in healthy aging adults are equivocal. Researchers have considered cognitive measures such as intelligence quotient (Miller, 2001) and working memory (Kemper, Marquis, & Thompson, 2001; Kemper et al., 1990; Kemper, Schmalzried, Herman, & Mohankumar, 2011; Miller, 2001; Norman, Kemper, Kynette, & Cheung, 1991) to explain age-related changes in syntactic complexity. Demographic factors such as years of education (Kemper & Mitzner, 2001; Kemper et al., 1990; Nippold et al., 2013), and linguistic factors such as vocabulary (Kemper et al., 1990; Kemper & Sumner, 2001; Kynette & Kemper, 1986; Nippold et al., 2013) have also been investigated as variables influencing the diminished use of complex syntax in late adulthood. At present the explanation with the strongest theoretical support is that syntactic changes in adulthood are driven by a

decline in working memory capacity (Burke & Shafto, 2008). However, the relationship between syntactic complexity and working memory has not been subjected to extensive scientific testing across various narrative discourse tasks.

Syntactic analysis of narrative discourse has also contributed to our knowledge of language deficits in those with pathological aging such as Alzheimer's disease (Bates, Harris, Marchman, & Wulfeck, 1995; de Lira et al., 2011; Forbes-McKay & Venneri, 2005; Hirst & Wei Feng, 2012; Kavé & Levy, 2003; Kemper et al., 2001; Murray, 2010; Sajjadi, Patterson, Tomek, & Nestor, 2012). The syntactic analysis of discourse samples from aging populations with neurological disorders, such as Alzheimer's disease, can provide a measure of syntactic complexity in everyday language use. However, without sufficient knowledge of typical aging patterns of productive syntax and cognitive factors that may influence the decline, it remains unclear whether a decline in syntactic complexity occurs as a product of pathological aging or due to healthy aging alone. Knowledge of the typical aging patterns of language production is essential to understanding and accurately identifying communication deficits in abnormal, pathological aging, such as dementia in general and Alzheimer's disease in particular (Mackenzie, 2000; Shadden, 1997).

In summary, though the general consensus in the literature confirms an age-related decline in syntactic complexity, questions remain. First, it is not clear how different types of narrative discourse (i.e. picture description versus a recount) affect the production of complex syntax in healthy aging adults. And second, the observed age-related decline in syntactic complexity is most commonly attributed to a diminished

working memory capacity (Burke & Shafto, 2008); however, studies exploring this relationship have yielded equivocal results.

Therefore, *the purpose of the present study is to explore the influence of task type and working memory on the syntactic complexity of narrative discourse production in healthy aging adults.*

This study addresses the following research questions:

1. Is there a relationship between syntactic complexity of a single picture description and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a single picture description and working memory differ as a function of age?

   It is hypothesized that syntactic complexity of a single picture description will be significantly, positively correlated with working memory such that higher syntactic complexity scores will correlate significantly with higher working memory scores. It is hypothesized that a significant, positive relationship between syntactic complexity and working memory will be present across age cohorts.

2. Is there a relationship between syntactic complexity of a sequential picture description and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a sequential picture description and working memory change as a function of age?

   It is hypothesized that syntactic complexity of a sequential picture description will be significantly, positively correlated with working memory score such that higher syntactic complexity scores will correlate significantly with higher

working memory scores. It is hypothesized that a significant, positive relationship between syntactic complexity and working memory will be present across age cohorts.

3. Is there a relationship between syntactic complexity of a storytelling and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a storytelling and working memory differ as a function of age?

   It is hypothesized that syntactic complexity of a storytelling will be significantly, positively correlated with working memory score regardless of age such that higher syntactic complexity scores will correlate significantly with higher working memory scores. It is hypothesized that a significant, positive relationship between syntactic complexity and working memory will be present across age cohorts.

4. Is there a relationship between syntactic complexity of a recount and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a recount and working memory change as a function of age?

   It is hypothesized that syntactic complexity of a recount will be significantly, positively correlated with working memory score regardless of age such that higher syntactic complexity scores will correlate significantly with higher working memory scores. It is hypothesized that a significant, positive relationship between syntactic complexity and working memory will be present across age cohorts.

Chapter Two: Review of the Literature

The following literature review examines previous research related to the syntactic complexity of narrative discourse production in healthy aging adults. Furthermore, the review explores the influence of narrative discourse task type and working memory on the diminished use of complex syntax in late adulthood.

While some areas of language processing and production are thought to remain invariant to age (e.g. semantic memory), other aspects of language are thought to be susceptible to age-related decline (Kemper & Mitzner, 2001)- syntactic complexity is one such area. Thus far, research exploring the syntactic complexity of narrative discourse in the healthy aging adult population has revealed that in general, older adults produce sentences of lower syntactic complexity as compared to young adults (Burke & Shafto, 2008).

The influence of task type on age-related decline in syntactic complexity

There are a number of tasks used to elicit narrative discourse samples, including eventcasts (explanation of an activity scene or a picture description), stories (a fictionalized narrative with predictable structure), and recounts (retelling of an event) (Heath, 1986). Depending on the degree of constraint inherent in these tasks, they can be described as: constrained (i.e. eventcasts), semi-constrained (i.e. storytelling), and unconstrained (i.e. recounts). The level of constraint present in different tasks may influence the nature of language sample produced. For example, a constrained task, such as picture description, seeks to eliminate the pragmatic and personal factors associated with unconstrained tasks, such as a recounting an event (Kemper et al., 2011). However, unconstrained discourse tasks, such as a recount, may provide a more realistic and natural

language sample than highly constrained tasks. Another factor to consider is that contrary to unconstrained tasks, constrained and semi-constrained tasks often provide scaffolding in the form of physical pictures; these pictures often include a setting, characters, and action sequences that the speaker that may use to facilitate the production of a narrative. The syntactic complexity of narrative discourse in the healthy aging adults has been investigated in the context of picture descriptions, storytellings and recounts.

Age-related declines in the syntactic complexity of picture description tasks. Event casts (i.e., picture description) is considered a constrained task as it is highly structured and provides a significant amount of scaffold for the speaker (Heath, 1986). Picture descriptions are often used clinically and in research to elicit narrative discourse samples (Cooper, 1990; Marini et al., 2005). Picture-supported stimuli have been found to be less taxing on a speaker's memory since the stimulus is available visually throughout language sample collection (Mackenzie, 2000). Cooper (1990) investigated changes in syntactic complexity as a function of healthy aging by comparing the performance of older and younger persons on a picture description task. Eighty adults between the ages of 20 and 78 participated in the study and were distributed across six age cohorts: 20s ($n=14$); 30s ($n=13$); 40s ($n=13$); 50s ($n=13$); 60s ($n=13$); 70s $n=14$). Three line drawings were used for the task: the Cookie Theft picture (Goodglass & Kaplan, 1983) and two other pictures designed by the investigator, which included the same number of content elements as the Cookie Theft picture. Participants were instructed to describe the stimuli in as much detail as possible and there was no time limit. The syntactic complexity of discourse samples was determined by calculating the number of subordinate (i.e. dependent) clauses per 100 words.

Results indicated no associations between age and the syntactic complexity of the discourse samples. Based on these results, the authors concluded that one should not expect the syntactic complexity of discourse in healthy older adults to be different from younger adults. Accordingly, Cooper suggested that if a syntactic difference is present, it may be indicative of some process other than normal aging. However, Cooper conceded that the sample size of this study, which included well educated individuals (mean years of education= 15.71) and individuals of above-average socioeconomic status, could have restricted the findings.

Research suggests that the type of picture stimulus can have an effect on narrative production (Capilouto et al., 2005; Coelho, 2002; Marini et al., 2005). For example, in a single picture stimulus, speakers must infer the sequence of events. In contrast, sequential pictures provide an organized, temporal sequence of events. It has been hypothesized that single pictures may prompt the subject to simply list objects or events in the picture; whereas picture sequences can facilitate the organization of a story and encourage the speaker to produce a narrative (Capilouto et al., 2005). Marini et al. (2005) investigated age-related changes in syntactic complexity using both a single and sequential picture task to elicit the language sample. Sixty-nine healthy adults participated in the study and were divided into five age groups: very young adults (ages 20-25, n=10), young adults (ages 25-39, n=15), middle-aged adults (ages 40-59, n=18), young elderly (ages 60-74, n=15), and old elderly (ages 75-84, n=11). To eliminate education as a confounding variable, inclusion criteria included the stipulation that all participants had 13 years education, corresponding in Italy to completion of high school. Three narratives were elicited from each participant using one single picture stimulus from the Western Aphasia

Battery (Kertesz, 1982), and two cartoon stories with six pictures each, which have been used in research by Huber and Gleber (1982) and Nicholas and Brookshire (1993). Syntactic complexity was measured as a ratio of complex sentences to utterances. Complex sentences were defined as sentences that were formed by at least one independent and one dependent clause.

Results indicated no significant stimulus effect, the use of a single picture versus sequential picture to elicit discourse, on syntactic complexity. However, a significant group effect was present. The old elderly group (ages 75-84) demonstrated a significant decrease in syntactic complexity in comparison to the very young adults, the young adults, and the middle aged adults; however, the old elderly group did not perform significantly different than the young elderly group. Further analysis revealed a linear decrease in syntactic complexity across age groups. These findings, which confirm an age-related decline in syntactic complexity, were not consistent with other studies (Cooper, 1990; Glosser & Deser, 1992). These discrepancies in results may be attributed to differences in the type of stimulus used to elicit discourse production as well as morphological differences between Italian and English.

Age-related declines in the syntactic complexity of storytelling tasks. The influence of age on syntactic complexity has also been explored using a semi-constrained task such as storytelling. Stories are considered semi-constrained as these tasks are less constrained than a picture description task; yet they have highly predictable structures and speakers may use the provided pictures as a scaffold (Heath, 1986). Researchers have used wordless picture books to elicit narrative discourse samples from adults for further analysis (Ash et al., 2006; Fergadiotis, Wright, & Capilouto, 2011; Wright et al., 2011).

However there are no previous studies that use wordless picture books to examine age-related changes in the syntactic complexity of healthy adults.

Storytelling, without the use of a wordless picture book, has been employed as a semi-constrained task to examine the syntactic complexity of discourse in healthy aging adults. This task differs from the current studies semi-constrained task as it does not provide a wordless picture book; however, the familiarity and predictable structure of a story can act as a scaffold for the storyteller. For example, Kemper et al. (1990) compared narrative discourse performance of healthy aging adults, in the context of a storytelling. Sixty-two elderly adults were divided into three age groups: ages 60-69 (n=28), 70-79 years (n=22), and 80-90 years (n=12). Participants were instructed to tell a story: a made up story like one might tell a child or a familiar story. The subsequent syntactic analysis focused on the number of clauses per utterance and the type of clause, using procedures from Kemper, Kynette, Rash, O'Brien, and Sprott (1989). The authors also investigated the relationship between discourse measures and participants' performance on cognitive measures, including working memory.

Authors specified that 58% of the language samples collected were personal narratives relating events from the storyteller's life (familiar story), whereas 42% were fantasy (made-up) narratives. The data from the personal and fantasy narratives were combined because analysis indicated that there was no significant effects of story type on syntactic complexity. Results revealed a significant age-related decline in the syntactic complexity of the narratives. Particularly, the mean number of clauses per utterance decreased with age. To investigate the influence of working memory on syntactic complexity, the authors examined the relationship between participants' performance on

two measures of working memory, forward digit span and backwards digit span of the WAIS (Wechsler, 1958) and their syntactic complexity scores. Authors reported a significant, positive correlation between performance on the backward digit span and syntactic complexity scores: adults with greater backward digit spans produced narratives with more clauses per utterance. Authors suggest that working memory is required to produce syntactically complex narratives and that a decrease in working memory capacity may impair elderly adult's production of complex sentences.

Age-related declines in the syntactic complexity of recount tasks. The influence of age on syntactic complexity of discourse samples has also been investigated using unconstrained tasks, such as a recount. A recount is a verbal reiteration of an event (Heath, 1986). Speakers often recount experiences from everyday life in episode-like sequences of events, with emphasis on temporal relations of events (Heath, 1986; Liles, 1993). Kynette and Kemper (1986) investigated recounts of a group of healthy adults between the ages of 50 and 89 years, in the context of an interview. Thirty-two native English speakers were divided into four age groups: 50-59 years, 60-69 years, 70-79 years, and 80-89 years; each group contained four women and four men. Participants were asked to recount events about their own lives such as their first job, war experiences, or marriage. A sample of 50 consecutive utterances was selected from the middle portion of the language sample for analysis. Sixteen different measures of syntactic structure, verb tense, form class, lexical use and disfluency were examined to provide a comprehensive profile of adults' spoken language. Of relevance to the present study are the results related to syntactic complexity.

Analysis revealed a significant relationship between age and the number of complex syntactic structures used, regardless of education level or employment status of participants. Specifically, the 50 year olds used more complex structures than did the other adults. The 50 and 60 year olds used more grammatical forms (*M*=43) and used them more correctly, as compared to the 70 and 80 year olds (*M*=38). Authors postulated that elderly adults used simpler grammatical constructions to avoid the high memory demands of more complex syntax. However, no working memory measure was included in the study to confirm the hypothesis.

Glosser and Deser (1992) collected recounts, in the context of informal interviews, from middle-aged and elderly adults. This study compared age-related changes in microlinguistic and macrolinguistic aspects of discourse production. Fourteen middle aged adults ranging in age from 43-61 (*M*=51.9) and 13 healthy elderly participants ranging in age from 67-88 (*M*= 76.2) participated. There were no significant differences between the middle-aged and elderly groups in terms or the proportions of males and females and mean years of education. Subjects were individually interviewed and asked to describe his/her family and then recount a work experience from his/her past. Of importance to the present study, the elicited language samples were analyzed for syntactic complexity using the Weighted Index of Subordination(Loban, 1963).

The results indicated that there was no statistically significant age group effect on the syntactic complexity of participants' narratives. The syntactic complexity measures did not discriminate between the middle-aged and elderly groups. However, authors proposed that there was suggestive evidence of a reduction in the syntactic complexity of discourse with advanced aging. For example, elderly subjects' had a lower absolute score

on the Weighted Index of Subordination and produced fewer embedded subordinate clauses than middle-aged subjects. Authors hypothesized that limitations in underlying cognitive functions such as working memory may inhibit the production of complex syntax in the elderly; however, no working memory measures were included in the study.

Miller (2001) examined the relationship between the syntactic complexity of recounts and specific components of working memory in healthy aging adults. A total of 60 participants were divided into three groups, each containing 20 adults: Group 1, early adulthood (25-35 years); Group 2, mid-adulthood (50-60 years); and Group 3, late adulthood (75-85 years). To obtain a discourse sample of at least 50 utterances, speakers provided a recount of an important event in their lives or an autobiographical experience. All utterances were coded by the author as either containing a simple sentence (one main clause), a complex sentence (one main clause and one subordinate clause), or a complex structure combination (one or more main clauses, and two or more subordinate clauses). Then three measures of syntactic complexity were computed: number of simple sentences, number of complex sentences, and number of complex structure combinations. Participants also completed three measures of working memory including: a phonological working memory span score (Belleville, Rouleau, & Caza, 1998), the Random number generation task, thought to measure the attentional control of working memory (Baddeley, 1986), and the n-Back Lag Task, designed to measure working memory capacity (Kwong See & Ryan Bouchard, 1995).

Analysis indicated significant age group differences in the syntactic complexity the adults generated during narrative discourse. Specifically, 75-85 year old participants produced significantly fewer complex structure combinations (i.e., the use of one or more

main clauses and two or more subordinate clauses) than the 50-60 and 25-36 year old

participants. The 75-85 year olds also used significantly fewer complex sentences (i.e.

one main clause and one subordinate clause) than the 25-36 year olds but not the 50-60

year old participants. Age group membership was also found to significantly interact

with a measure of working memory capacity, the lagscore, from the n-Back Lag Task.

The 25-35 year old participants' mean lagscore was significantly higher than 50-60 year

olds and the 75-85 year olds; while there was no significant difference on the mean

lagscore between the 50-60 year olds and the 75-85 year olds. Results also indicated

significant relationships between syntactic complexity and a measure of working memory

capacity, the lagscore. For the total sample, lagscore was significantly, positively

correlated with complex structure combinations. However, when correlational analysis

was performed by group the use of complex sentences was significantly correlated with

the lagscore only in the 25-35 year age group. Of particular importance, the results of

this study revealed that syntactic complexity could be predicted by measures of working

memory capacity. Specifically, the working memory capacity measure, lagscore, and the

Random number generation task were significant predictors of complex structure

combinations used by the adult participants, regardless of age.

The influence of working memory on age-related changes in syntactic complexity

Characteristically, the syntactic complexity of one's language is determined by

the amount of embedded clauses used, and in some studies, the type of embedded

clauses. It is postulated that syntactically complex sentences place a burden and increased

demand on working memory. Kemper et al. (2001) explains, "Embeddings, in which the

embedded clause precedes or interrupts the main clause, typically require that the

grammatical form of the main clause be anticipated while the embedded clause is being produced, thus adding to the burden on working memory" (p. 601). This theory, in conjunction with well-established evidence of decreased working memory capacity in older adults (Myerson, Emery, White, & Hale, 2003; Salthouse & Babcock, 1991), may explain the preference of older adults to use simplified the syntactic structures. Further evidence of a cognitive-linguistic relationship between working memory and syntactic complexity has been found more recently using brain imaging techniques. Researchers have found close neural interactions between language production systems and verbal working memory in the inferior frontal gyrus region of the brain (Timmers, van den Hurk, Di Salle, Rubio-Gozalbo, & Jansma, 2011).

Older adults have been found to have a smaller working memory capacity than young adults and measures of working memory capacity have been found to correlate with measures of syntactic complexity (Kemper et al., 1990; Miller, 2001). However, while it has been demonstrated that working memory capacity declines with age, there is ambiguity surrounding the influence this has on diminished use of complex syntax in the language of older adults. Much of this ambiguity is due to the lack of consistency in conceptualizing and measuring working memory. For example, in the context of studies investigating the role of working memory on the age-related declines in syntactic complexity, several different measures have been used to quantify working memory. These measures include the forward digit span and backward digit span of the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1958), the reading span test (Daneman & Carpenter, 1980), the n-back (Kirchner, 1958), the n-back lag task (Kwong See & Ryan Bouchard, 1995), and the Random number generation task (Baddeley, 1986). Similarly, a

discussion of how working memory is conceptualized is often missing from studies. Stronger conclusions about the cognitive-linguistic relationship between syntactic complexity and working memory can be made when working memory test results are considered within a theoretical framework (Wright & Fergadiotis, 2012).

  Theoretical framework of Working Memory. Several frameworks have been developed to conceptualize working memory; in the current study, working memory will be viewed under the *multi-component model* of working memory, initially proposed by Baddeley and Hitch (1974). Baddeley (2010) defines working memory as "the system or systems that are assumed to be necessary in order to keep things in mind while performing complex tasks such as reasoning, comprehension and learning" (p. 136). The *multi-component model* divides working memory into four subsystems, each of which has a limited capacity for storing and processing information (Appendix A). The *central executive* is a domain-general subsystem, assumed to be responsible for the attentional control of working memory as well as the processing and storage of information. The central executive system controls two slave systems the *phonological loop* and the *visuospatital sketchpad*, each of which processes domain specific material. The *phonological loop* processes verbal and acoustic information. It is comprised of two subcomponents: a phonological input store, which holds verbal memory traces for a matter of seconds, and an articulatory rehearsal process, which is analogous to subvocal speech and responsible for rehearsing verbal information and recycling it to refresh the memory trace. The *visuospatial sketchpad* integrates spatial and visual information into an integrated representation which may be temporarily stored and manipulated. The last subsystem of multi-component model of working memory, the *episodic buffer*, is a

subsystem that allows for interaction among the two slave systems and long term memory by binding together information from different sources (i.e., verbal, visual, spatial) into chunks or episodes. Baddeley (2003) asserts that working memory underpins our ability to think, and consequently, has important implications for language processes.

Working memory measures: Span tasks. Discrepancies in the conceptualization of working memory has led to similar uncertainty regarding what features a task must have to qualify as a valid measure of working memory capacity. Working memory span tasks are widely used measures of working memory capacity (Conway et al., 2005). Span tasks can be characterized as simple or complex. Simple span tasks (e.g., forward digit span or word span), were created to measure the capacity for information storage and rehearsal. Complex span tasks (e.g., reading span or backwards digit span) were designed to measure the capacity for not only information storage and rehearsal, but also the simultaneous processing of additional information. Complex span tasks were designed from the perspective of the *multi-component model* (Baddeley & Hitch, 1974). They present target stimuli to be remembered along with the presentation of a demanding secondary processing task, such as comprehending sentences or manipulating numbers (Conway et al., 2005). Complex span tasks are assumed to measure an individual's capacity to store and rehearse information, which occurs in the *phonological loop* or *visuospatial sketchpad*, depending on the type of input; and also to process and manipulate information, which occurs in the *central executive system* (Hale et al., 2011).

Age-related changes in simple versus complex span tasks. It is well established that older adults perform more poorly on measures of working memory capacity than do younger adults (Hale et al., 2011; McCabe & Hartman, 2003; Myerson et al., 2003;

Salthouse, Hancock, Meinz, & Hambrick, 1996). However, ambiguity remains regarding how age-related declines differ for simple versus complex and verbal versus visuospatial span tasks, and further, which span tasks most accurately measure working memory capacity. In a meta-analysis, Bopp and Verhaeghen (2005) examined age differences in simple verbal span tasks versus complex verbal spans tasks. The study found the presence of age-related differences in both simple and complex span tasks, but as a processing component was added (a complex span task) the age differences became much larger. The authors concluded that older adults are more impaired on verbal tasks that require both processing and storage (complex span tasks) than on tasks requiring only storage (simple span tasks).

A study by (Hale et al., 2011) investigated adults performance on simple versus complex span tasks. A total of 388 adults, ranging in age from 20-89, were administered six pairs of working memory span tasks. Each pair included a simple span task and a complex span task. The type of memory (verbal information or visuospatial information) was the same for both members of a pair, but differed across pairs. Consistent with the hypothesis of an age-related deficit in the executive component of working memory, results revealed that performance on complex span tasks decreased at a faster rate as a function of age than simple span tasks for both verbal and visuospatial information. Furthermore, in a methodological review of working memory span tasks. Conway et al. (2005) asserted that span tasks must include a demanding secondary task (i.e., complex span task) to effectively measure working memory capacity.

Age-related changes in verbal versus visuospatial span tasks. Studies have also investigated how age-related changes may differ between verbal memory spans (the

phonological loop) and spatial memory spans (visuospatial sketchpad). Evidence from

two major studies revealed that age-related differences between older and younger adult's

verbal spans were much smaller than the difference between their spatial spans (Jenkins,

Myerson, Joerding, & Hale, 2000; Myerson et al., 2003). Specifically, Myerson et al.

(2003) analyzed cross-sectional data from the normative sample of the Wechsler Memory

Scale – Third Edition (WMS-III). Working memory measures of the WMS-III include,

forwards and backwards Digit Span, forwards and backwards Spatial Span (a visual-

spatial analog of Digit Span), and Letter-Number Sequencing. Two of these measures,

forwards and backwards Spatial Span and Letter-Number Sequencing, are the tests used

in the current study to measure working memory capacity. The results revealed different

patterns of age-related differences in working memory measures depending on the type of

memory item, verbal versus spatial. For example, Spatial Span (visuospatial information)

raw scores decreased as a function of age at approximately twice the rate of Digit Span

raw scores (verbal information). Also, scores on the Letter-Number Sequencing subtest (a

complex verbal span task) decreased more as a function of age than scores on the Digit

Span subtest (combined score of forward and backwards digit span), but scores on the

Spatial Span subtest (combined score of forward and backwards spatial span) showed the

largest decrease.

In sum, considering the ambiguous nature of working memory itself, no single

task can be verified as a perfect measure of working memory capacity. Although complex

span tasks have been shown to be reliable measures of working memory, they are not

"process pure" (Conway et al., 2005, p. 780). For example, the operation span is reliable

for testing working memory capacity but undoubtedly taps into other cognitive constructs

such as motivation and mathematical ability (Conway et al., 2005). Conway et al., (2005)

proposed that the scores of multiple types of working memory spans tasks should be

averaged to gain the most comprehensive and accurate measure of working memory.

Accordingly, to measure the working memory of participants in the current study, the

Wechsler Memory Scale—Third Edition (WMS–III; Wechsler, 1997a) was administered.

A raw working memory score was derived from the sum of scores on two subtests: a

complex verbal span task (Letter-Number Sequencing) and a complex visuospatial span

task (Spatial Span).

Chapter Three: Methods

Participants

Data used in the present study were taken from a larger study investigating discourse processing in a random selection of healthy adults across the lifespan. Data from 180 participants were selected across three age cohorts, 20-29 year olds in the young group (YG), 60-69 year olds in the older group (OG) and 75-89 year olds in the elderly group (EG). Each cohort consisted of 60 individuals, with varying number of males and females. See Table 3.1 for each cohort's demographic data of interest.

Participants met the inclusion criteria set by the larger study- which included: (1) self-reported native English speaker (2) no self-reported history of a neurological condition (i.e.- stroke) or previous head injury; (3) no self-reported history of cognitively deteriorating conditions (i.e.- Alzheimer's, Parkinson's) and a score of 29 or above on the *Mini-Mental Status Examination* (Folstein & Folstein, 2002); (4) no depression at the time of participation as indicated by a score of 0-4 on the Geriatric Depression Scale-Short Version (Yesavage, 1988) (5) functional hearing abilities measured by the CID List of Everyday Speech (Davis & Silverman, 1970) (6) functional visual abilities measured by passing a vision screening (Beukelman & Mirenda, 1998).

Experimental Procedures

Following consent, participants attended two sessions, each lasting no longer than two hours. One session was designated for cognitive testing and one for the collection of discourse samples; the order of the sessions was randomized. A trained graduate assistant individually tested and collected language samples from each participant.

Cognitive Measures

For the cognitive session, participants completed standardized measures of memory and attention. These measures included the Wechsler Memory Scale—Third Edition (WMS–III; Wechsler, 1997a), Comprehensive Trail Making Test (CTMT; Reynolds, 2002) and Stroop Color and Word Test (STROOP; Golden, 2002). For the current study, only the working memory raw score of the WMS–III was used in the analyses. The working memory raw score estimated participants' ability to attend to information, temporarily store and manipulate that information, and then formulate a response based on that information. Participants with a mean score above 25.17 were placed in the high working memory group, while those with an average below 25.17 were placed in the low working memory group (see Table 3.2).

The WMS-III working memory raw score is derived from the sum of the raw scores of two complex span tasks: Letter-Number Sequencing and Spatial Span. The Letter-Number Sequencing subtest is a measure of auditory-verbal working memory. This task assesses the examinee's ability to simultaneously remember and re-sequence a series of numbers and letters. The administrator verbally presents a sequence of alternating letters and numbers, which gradually increases from 2 to 8 elements. The examinee is prompted to repeat the numbers in ascending numerical order and then the letters in alphabetical order. Examinees are given three trials at each sequence length, and continue until all three trials of a series length are failed. The maximum possible score is 21. The Spatial Span subtest, a visual analog to the familiar digit span task, is a measure of visual-spatial working memory. This task assesses the examinee's ability to hold and manipulate a sequence of visual-spatial events in working memory. The Spatial Span

subtest consists of two parts: Spatial Span Forward and Spatial Span Backward. The administrator taps a series of cubes on the spatial span board and the examinee is asked to mirror each sequence in the same order as the examiner (Spatial Span Forward) or in reverse order (Spatial Span Backward). The test begins with sequence of two cubes and continues to a maximum of eight cubes. The maximum possible score for the Spatial Span subtest is 32.

Discourse Tasks

In the discourse session, a total of eleven discourse samples were collected from each participant, with the order of tasks randomized. The discourse samples included: 4 picture descriptions, 2 story retellings, 3 recounts, and 2 procedural descriptions. Prior to the completion of each discourse task, scripted directions were read to participants and an example of the task stimulus was provided. In the present study, four of the eleven collected discourse samples were selected for analysis to include constrained, semi-constrained, and unconstrained narrative discourse tasks.

For the constrained task, participants described two picture stimuli from Nicholas and Brookshire (1993), 'Cat in the Tree' and 'Directions'. 'Cat in the Tree' is a single picture that illustrates a man attempting to rescue a girl's cat that has been chased up a tree by a dog. The man becomes stuck in the tree when his ladder falls down; and so fire fighters come to rescue the man and the cat (Appendix B). 'Directions,' is a six-framed picture sequence depicting a couple asking a farmer for directions. The first frame portrays the man and woman stopped alongside of the road in their car, asking the farmer for directions. The subsequent frames show the man and woman driving away, the farmer

continuing to plant his tree, and lastly the man and woman returning back to the same spot (Appendix C).

To explain the task, the examiner read the following script: *"Let's look at this picture. I am going to tell you a story with a beginning, a middle and an end."* The examiner then showed the participant the Cookie Theft picture (Goodglass & Kaplan, 1983) (Appendix D). *"A little boy is trying to get a cookie from the cookie jar. He wants one for his sister also. He climbed on the stool to get the cookie and is about to fall. His mother is not paying attention to anything that is going on. She is staring out the window while the water in the sink is overflowing.* Following the demonstration, the examiner said, *"Now it is your turn. Take a minute to look at this picture. When you are ready, tell me a story with a beginning, middle, and end."* If participants spoke for less than 15 seconds, they were prompted with *"Is there anything else you can tell me?".*

For the semi-constrained task, participants told a story derived from the wordless picture book, "Picnic" (McCully, 1984). "Picnic" includes no text other than the title and depicts a mouse family preparing to go on a picnic. The story begins with the mouse family climbing into a truck to drive to their picnic destination. When the truck hits a rock, the baby mouse and her stuffed animal are thrown onto the street. The family unknowingly continues on and the story teller is then presented with a series of pictures from the family picnic as well as pictures of the adventures the baby mouse on her own. Finally, both story lines merge together, as the mouse family searches for and reunite with the baby mouse. The language samples from "Picnic" were selected for analysis in this study, since the presence of both spatial and temporal components would likely yield a more complex language sample as compared to a story that was only temporally driven

(Appendix E). To explain the story task, the examiner read a script using the wordless picture book, *The Great Ape* (Krahn, 1978) (Appendix F). Demonstration of the task was followed by the prompt, *"Now it is your turn. Look at this book and when you are ready tell me the story that goes with the pictures."*

For the unconstrained task, participants were asked to recount their previous weekend. The 'Weekend' language samples were chosen for analysis as they were hypothesized to limit the memory constraints that may be imposed by recounting more distant events, such as a holiday or vacation. To explain the task, the examiner read the following script: *"I am going to tell you about a recent experience. Let me tell you about my Spring Break. My family and I took a trip to Daytona Beach, Florida. There were five of us. We drove and it took us 20 hours to get there. We spent the days lying on the beach getting a sun burn and at night we went out for dinner and then played Putt-Putt. We had a great time!"* Demonstration of the task was followed by a prompt, *"Now it is your turn. Tell me what you did last weekend."* If participants spoke for less than 15 seconds, they were prompted with *"Is there anything else you can tell me?"*

Language Transcription and Analysis

Language samples were independently transcribed and analyzed by trained assistants. Training followed a multi-step procedure. First, assistants were provided with detailed rules for transcription and analysis. This was followed by a series of example transcripts, with the analyses completed and explanations as to why a verbalization was segmented or scored correctly or incorrectly. Next, assistants completed practice activities whereby scorers could compare their results to previously scored transcripts of the same language samples, again with explanations provided. With the completion of

training, assistants orthographically transcribed each language sample from an audio or video recording.

The orthographically transcribed language samples were segmented into C-units for later analyses. A C-unit is a syntactic unit consisting of an independent clause with all its modifiers or dependent clauses (Loban, 1976). Clauses are the basic foundation of a sentence; a clause contains a subject and a predicate. An independent clause (IC) can stand alone as grammatically correct whereas a dependent clause (DC) is traditionally defined as not being able to stand alone as grammatically correct. Research assistants were instructed to have the C-unit segmentation rules accessible when segmenting written transcripts into C-units and to refer to the audio recording if there was any ambiguity in the written transcript.

The syntactic complexity for each language sample was measured by calculating a complexity index. This index was developed by Capilouto and Wright (2007) (unpublished) and fashioned after the work of Schneider, Dubé, and Hayward (2005). The complexity index provides a measure of the relative complexity of any given sample by examining the sample for clausal structure and embedding. Complex sentences are those that contain an independent clause plus one or more dependent clauses. In this specific index, other clauses that count as dependent clauses include, infinitive clauses, gerund clauses, past participles. A trained graduate assistant counted the total number of independent clauses (IC) and dependent clauses (DC) in each individual language sample, which had previously been segmented into C-units. The complexity index was then calculated based on the following formula: (total IC + total DC/ total IC). For example, in a transcript with 10 C-units, there are 10 independent clauses. And if there

were 11 dependent clauses in the transcript, the CI would be: 10+11/10= 2.1 (Appendix G).

Reliability

Ten percent of language samples were randomly selected for a second transcription to determine intra-rater and inter-rater reliability for word-by-word agreement and C-unit segmentation. Reliability was calculated based on the following formula: (total agreements / [total agreements + total disagreements] X 100). Intra-rater and inter-rater agreement for both measures was above 90 percent. Ten percent of language samples were randomly selected for determining intra-rater and inter-rater reliability for calculating the Complexity Index (CI). Reliability was subjected to the following formula: $100-[\Delta$ CI count/(total agreements + total disagreements)]. Intra-rater and inter-rater agreements were above 90%.

Statistical Analyses

The relationship between syntactic complexity, cohort, narrative discourse task type, and working memory age were analyzed using PASW Statistics 18 (SPSS Inc., 2001). To answer each question an independent samples t-test was conducted to determine if a relationship existed between syntactic complexity and working memory, regardless of age. To answer the second part of each question a two-way ANOVA was conducted to determine the effects of age and working memory on syntactic complexity scores for each discourse task. A significance level of alpha = .05 was used for all analyses. The following chapter will report the results of the study.

Table 3.1

Reported Means and (standard deviations) of Demographic Variables of Interest, By Age

Cohort (n = 60 per cohort)

	YG[1]	OG[2]	EG[3]
M:F	30:30	32:28	30:30
Age	24.27(2.72)	65.85(2.77)	81.78(3.78)
Education	15.72(1.85)	15.85(2.88)	14.98(2.89)
MMSE[4]	56.38(5.91)	55.20(6.84)	60.33(12.58)

[1]Young Group (20-29 year olds); [2]Older Group (60-69 year olds);

[3]Elderly Group (75-89 year olds) [4]Mini Mental Status Examination Scaled Score

Table 3.2

Reported Means and (standard deviations) of Demographic Variables of Interest, By

Working Memory Group (low or high)

	Low WM[1]	High WM[2]
Participants	88	92
M:F	45:43	43:49
Age	72.05(16.24)	43.20(22.77)
Education	15.23(2.99)	15.79(2.14)

[1]Participants had a Raw Working Memory Score below the mean (M=25.17);

[2]Participants had a Raw Working Memory Score above the mean (M=25.17)

Chapter Four: Results

Preliminary Analyses

Shapiro-Wilk normality tests indicated that data for all of the syntactic complexity variables were not normally distributed. Box-Cox analyses suggested that the simple inversion was a reasonable transformation for all of the syntactic complexity variables. Each variable was transformed using the inverse of the variable. Then to answer each research question, the transformed syntactic complexity variables were used as the dependent variable in all independent variable t-tests and in all two-way analyses of variance (ANOVA) models.

For the independent t-tests, participants were divided into two cohorts based on working memory score (low or high), regardless of age (see Table 3.2). Participants with a working memory score below the sample mean (M=25.17, SD=5.54) were placed in the low working memory group and participants with a working memory score above the mean were placed in the high working memory group. In the two-way ANOVA model, working memory group (low and high) and age cohort (young group, older group, and elderly group) were used as the independent variables. Preliminary analyses were conducted to ensure that years of education was not a contributing factor to results. Mean education level was 15.23 ($SD = 2.99$) years for the low working memory group and 15.79 ($SD = 2.14$) years for the high working memory group. A one-way ANOVA indicated no significant difference between low and high working memory cohorts with respect to years of education, $F(1, 178) = 2.145, p = .145$. Therefore years of education was not considered to affect working memory group assignment and was not considered in subsequent analyses.

Research Question 1: Is there a relationship between syntactic complexity of a single picture description and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a single picture description and working memory differ as a function of age?

An independent samples *t*-test was conducted to examine the difference in mean syntactic complexity score on the single picture description task for participants with low working memory scores and participants with high working memory scores. Results indicated a significant difference in mean syntactic complexity between the high working memory and low working memory groups, $t(178) = 3.032$, $p = 0.003$. Participants with high working memory had a significantly higher syntactic complexity score (*M*= 1.77, *SD*=.41) than those with low working memory (*M*=1.62, *SD*=.37) (see Figure 1).

To address the second portion of the question, a 2X3 (working memory X cohort) ANOVA was conducted. There was no significant interaction between the effects of cohort and working memory on syntactic complexity, $F(2,174)=.269$, $p=.764$, suggesting no differential effects between high working memory and low working memory cohorts, across age groups. A significant main effect for cohort was found, $F(2,176) = 2.95$, $p=.055$ (see Figure 2). Post-hoc Bonferroni analysis indicated that syntactic complexity was significantly greater for the young cohort (*M*=1.82, *SD*=.41) compared to the older group (*M*=1.66, *SD*=.39) and the elderly group (*M*=1.60, *SD*=.37); no other comparisons were significant. There was no main effect for working memory, $F(1,176)=1.160$, $p=.283$ (see Table 4.2).

Research Question 2: Is there a relationship between syntactic complexity of a sequential picture description and working memory in healthy adults? Does the nature of a

relationship between syntactic complexity of a sequential picture description and working

memory change as a function of age?

To examine the difference in mean syntactic complexity score on the sequential

picture description task for participants with a low working memory score and

participants with a high working memory score, an independent samples *t*-test was

conducted. Results indicated no significant difference in mean syntactic complexity

between the high working memory and low working memory groups, $t(178)= 1.470$, $p=$

0.143 (see Figure 3).

A 2X3 (working memory X cohort) ANOVA was conducted to investigate if the

relationship between syntactic complexity and working memory differed as a function of

age. There was no significant interaction between the effects of cohort and working

memory on syntactic complexity, $F(2,174)=2.376$, $p=.096$, suggesting no differential

effects between high working memory and low working memory cohorts, across age

groups. There was no main effect for working memory, $F(1,176)=.001$, $p=.973$, or

cohort, $F(2,176)=1.850$, $p=.160$ (see Table 4.3).

Research Question 3: Is there a relationship between syntactic complexity of a

storytelling and working memory in healthy adults? Does the nature of a relationship

between the syntactic complexity of a storytelling and working memory change as a

function of age?

An independent samples *t*-test was conducted to examine the difference in mean

syntactic complexity score on the storytelling task for participants with low working

memory scores and participants with high working memory scores. Results indicated a

significant difference in mean syntactic complexity between high working memory and

low working memory groups, $t(178) = 4.382$, $p = 0.000$. Participants with high working memory scores had a significantly higher mean syntactic complexity score ($M= 1.56$, $SD=.28$) than those with a low working memory score ($M=1.40$, $SD=.19$) (see Figure 4).

A 2X3 (working memory X cohort) ANOVA was conducted to answer the second portion of the question. There was no significant interaction between the effects of cohort and working memory on syntactic complexity, $F(2,174)=1.539$, $p=.218$, suggesting no differential effects between high working memory and low working memory cohorts, across age groups. A significant main effect for cohort was found, $F(2,176) = 13.250$, $p=.000$ (see Figure 5). Post-hoc Bonferroni analysis indicated that the mean syntactic complexity score was significantly higher for the young cohort ($M=1.64$, $SD=.29$) compared to the older cohort ($M=1.45$, $SD=.21$) and the elderly cohort ($M=1.35$, $SD=.14$). Also the older group ($M=1.45$, $SD=.21$) had a significantly higher mean syntactic complexity score as compared to the elderly group ($M=1.35$, $SD=.14$). There was no main effect for working memory, $F(1,176)= .482$, $p=.488$ (see Table 4.4).

Research Question 4: Is there a relationship between syntactic complexity of a recount and working memory in healthy adults? Does the nature of a relationship between the syntactic complexity of a recount and working memory change as a function of age?

To examine the difference in mean syntactic complexity score on the personal recount task for participants with low working memory scores and participants with high working memory scores, an independent samples *t*-test was conducted. Results indicated no significant difference in mean syntactic complexity between high working memory and low working memory groups, $t(178) = -.283$, $p= 0.777$ (see Figure 6).

A 2X3 (working memory X cohort) ANOVA was conducted to examine if the relationship between syntactic complexity and working memory differs as a function of age. There was no significant interaction between the effects of cohort and working memory on syntactic complexity, $F(2,174)=.865$, $p=.423$, suggesting no differential effects between high working memory and low working memory cohorts, across age groups. There was no main effect for working memory, $F(1,176)=.004$, $p=.950$, or cohort, $F(2,176)=2.316$, $p=.102$ (see Table 4.5).

Table 4.1

Reported Means and (standard deviations) of Syntactic Complexity Scores, by Working

Memory Group (low or high) for each Narrative Discourse Task

	Working Memory	
	Low[1]	High[2]
SC[3] of Single Picture Description	1.62 (.37)	1.77 (.41)
SC of Sequential Picture Description	1.60 (.35)	1.70 (.49)
SC of Storytelling	1.40 (.19)	1.56 (.28)
SC of Recount	1.40 (.33)	1.38 (.33)

[1]Participants had a Raw Working Memory Score below the mean (M=25.17);

[2]Participants had a Raw Working Memory Score above the mean (M=25.17);

[3]Syntactic Complexity

Table 4.2

Reported Means and (standard deviations) of Syntactic Complexity Scores from two-way ANOVA for Single Picture Description Task

	Syntactic Complexity Score	
	Working Memory	
Cohort	Low	High
YG[1]	1.74 (.29)	1.83 (.42)
OG[2]	1.62 (.39)	1.71 (.39)
EG[3]	1.61 (.37)	1.59 (.37)

[1]Young Group (20-29 year olds); [2]Older Group (60-69 year olds);

[3]Elderly Group (75-89 year olds)

Table 4.3

Reported Means and (standard deviations) of Syntactic Complexity Scores from two-way ANOVA for Sequential Picture Description Task

	Syntactic Complexity Score	
	Working Memory	
Cohort	Low	High
YG[1]	1.79 (.37)	1.75 (.56)
OG[2]	1.55 (.27)	1.71 (.38)
EG[3]	1.60 (.38)	1.41 (.24)

[1]Young Group (20-29 year olds); [2]Older Group (60-69 year olds);

[3]Elderly Group (75-89 year olds)

Table 4.4

Reported Means and (standard deviations) of Syntactic Complexity Scores from two-way ANOVA for Storytelling Task

| | Syntactic Complexity Score | |
| | Working Memory | |
Cohort	Low	High
YG[1]	1.62 (.20)	1.64 (.30)
OG[2]	1.41 (.22)	1.49 (.19)
EG[3]	1.36 (.15)	1.30 (.09)

[1]Young Group (20-29 year olds); [2]Older Group (60-69 year olds);

[3]Elderly Group (75-89 year olds)

Table 4.5

Reported Means and (standard deviations) of Syntactic Complexity scores from two-way ANOVA for Recount Task

	Syntactic Complexity Score	
	Working Memory	
Cohort	Low	High
YG[1]	1.46 (.40)	1.34 (.30)
OG[2]	1.43 (.34)	1.49 (.37)
EG[3]	1.37 (.31)	1.30 (.20)

[1]Young Group (20-29 year olds); [2]Older Group (60-69 year olds);

[3]Elderly Group (75-89 year olds)

Figure 1

Mean syntactic complexity score by working memory group (low or high) for single
picture description task

Figure 2

Mean syntactic complexity score by cohort and working memory group (high or low) for single picture description task

Cohort 1= Young Group (20-29 year olds); Cohort 2= Older Group (60-69 year olds);

Cohort 3=Elderly Group (75-89 year olds)

Figure 3

Mean syntactic complexity score by working memory group (low or high) for the

sequential picture description task

Figure 4

Mean syntactic complexity score by working memory group (low or high) for the

storytelling task

Figure 5

Mean syntactic complexity score by cohort by working memory group (high or low) for storytelling task

Cohort 1= Young Group (20-29 year olds); Cohort 2= Older Group (60-69 year olds);

Cohort 3=Elderly Group (75-89 year olds)

Figure 6

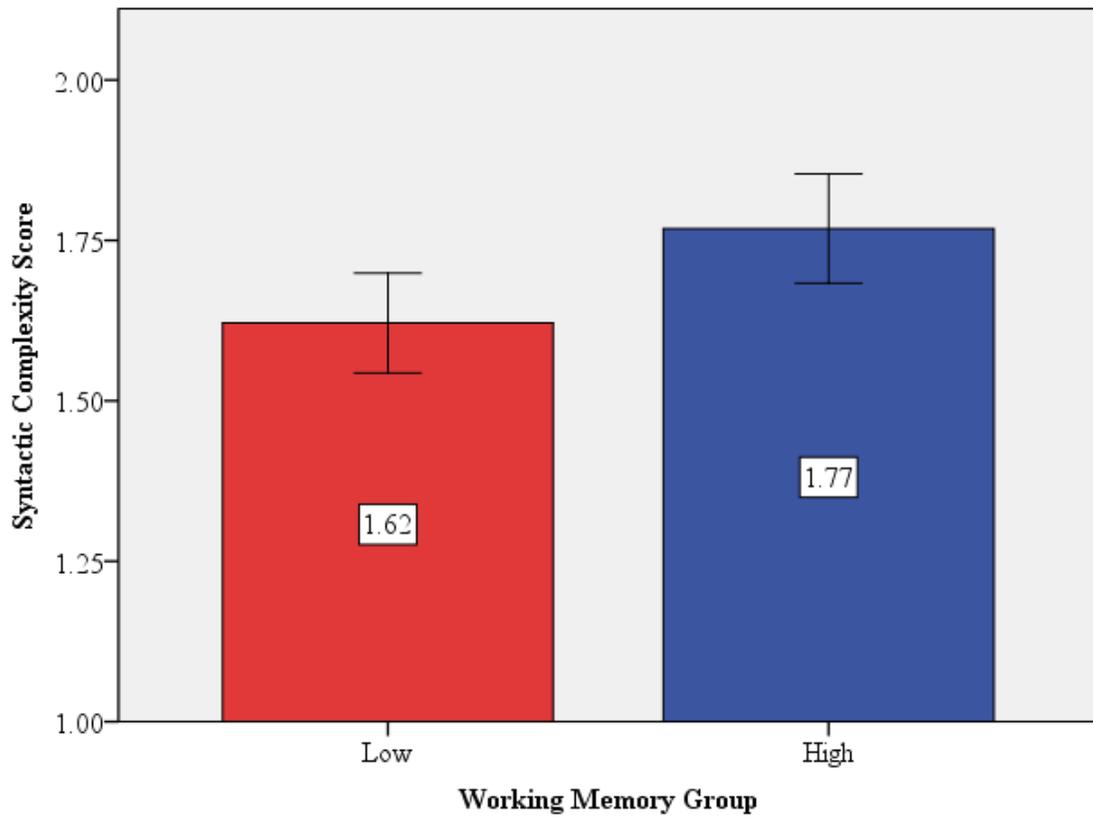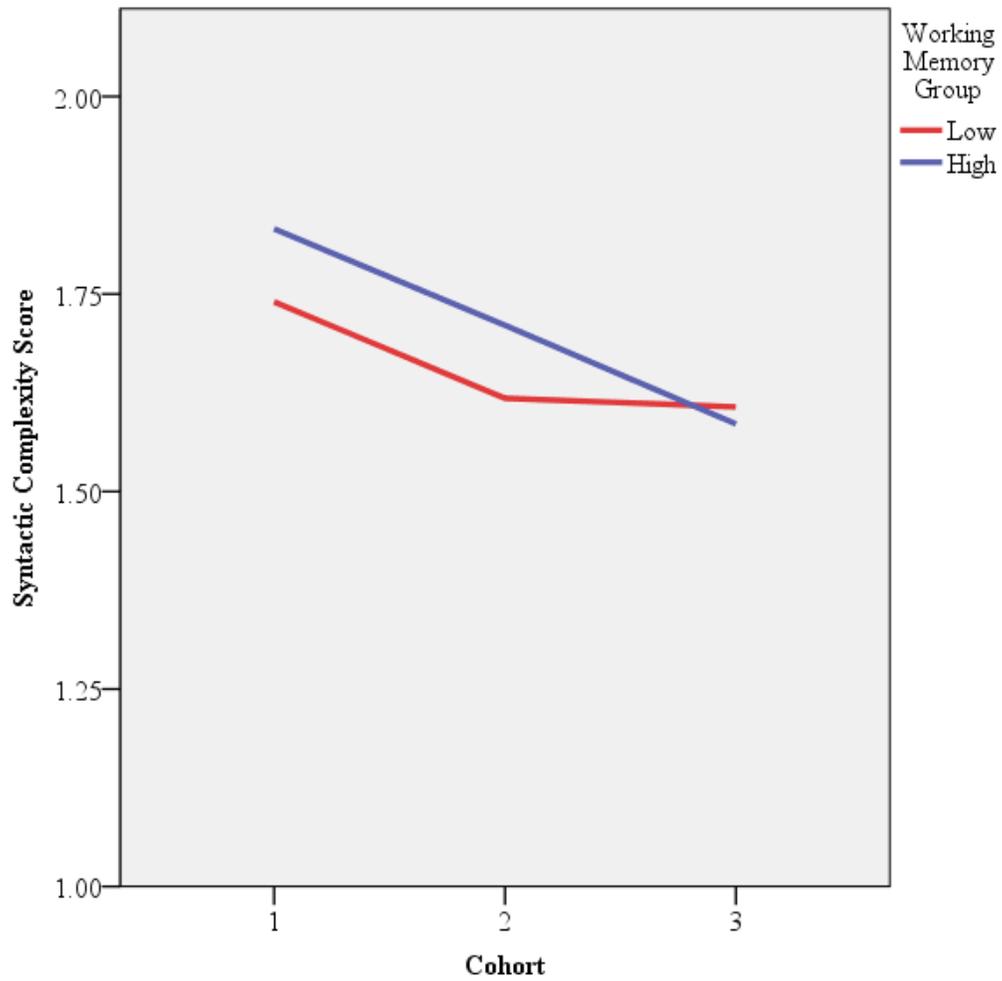Mean syntactic complexity score by working memory group (low or high) for the recount

task

Chapter Five: Discussion
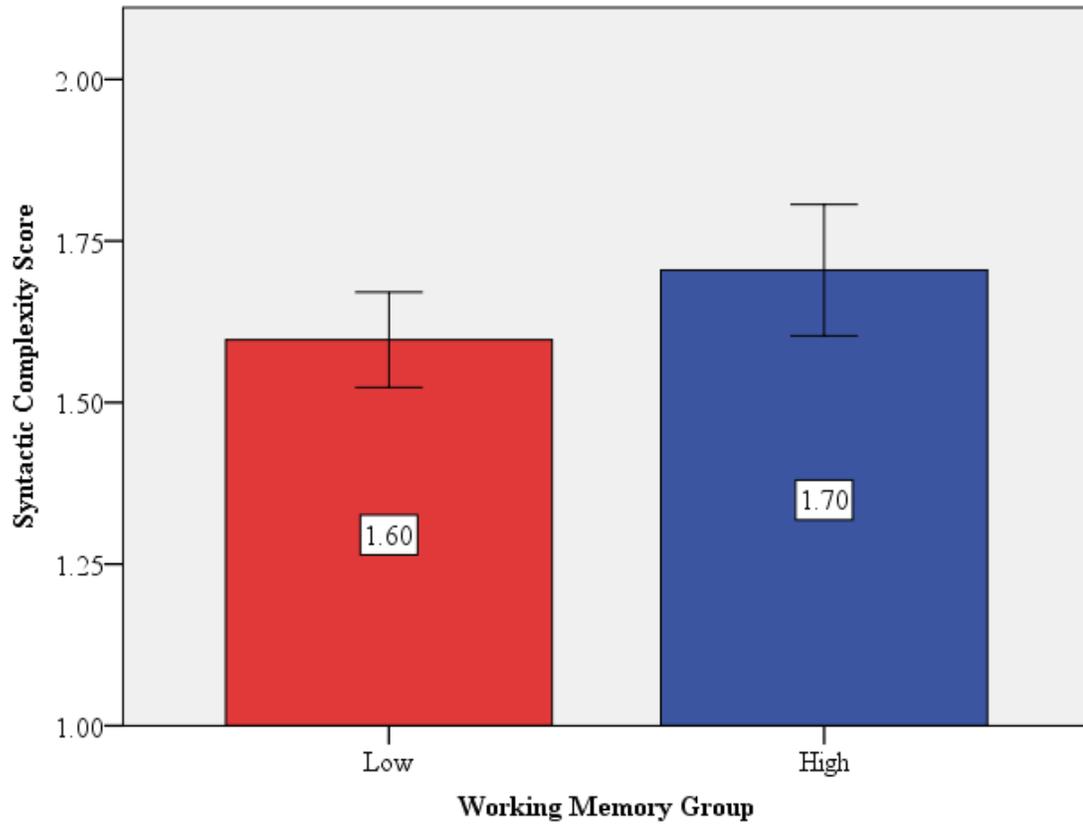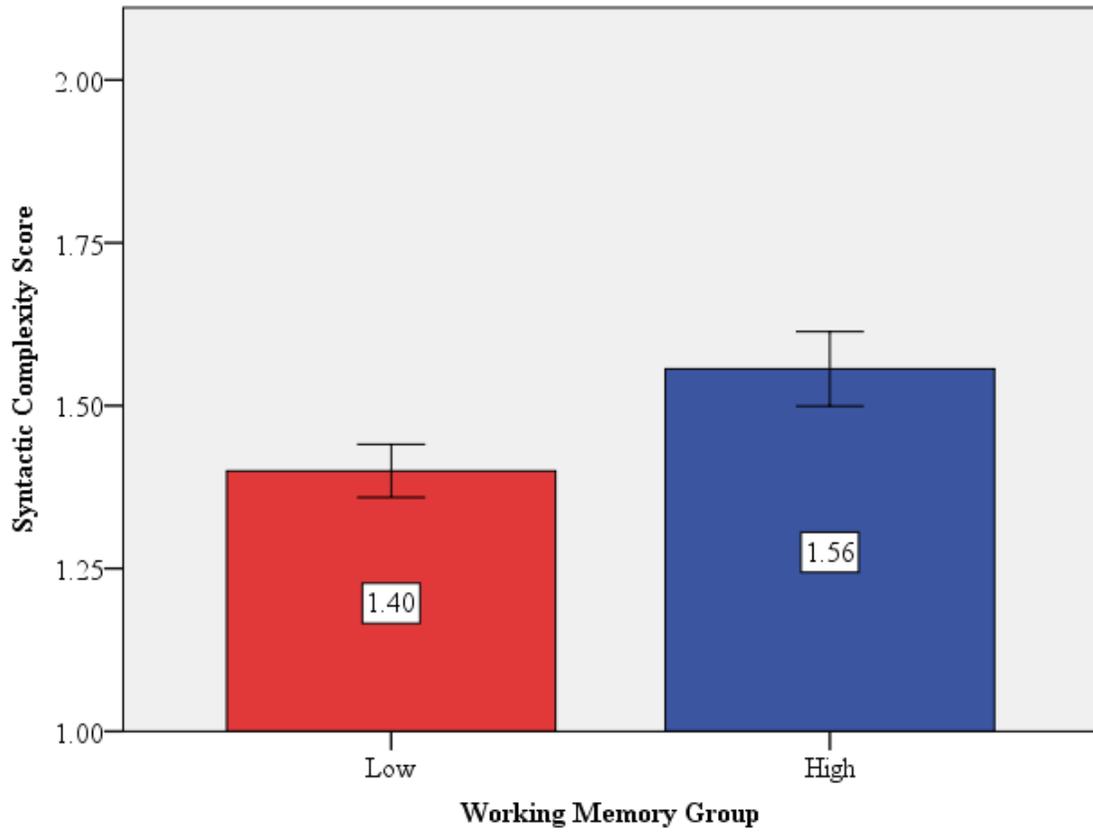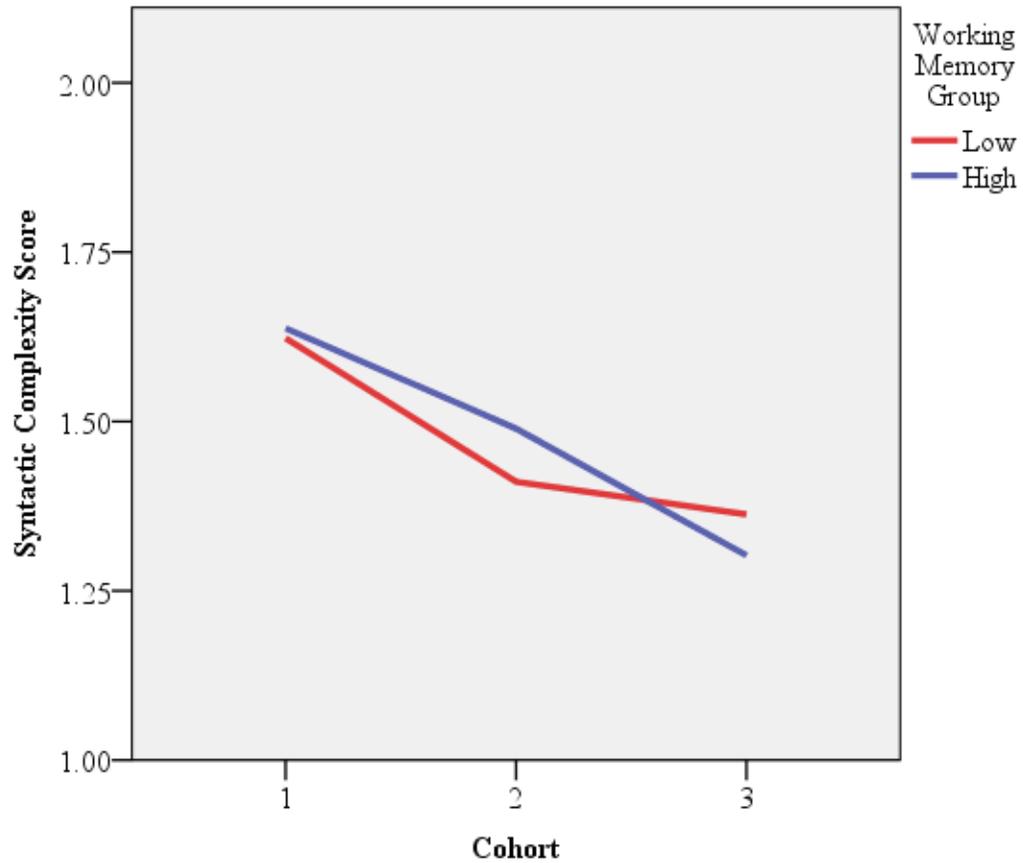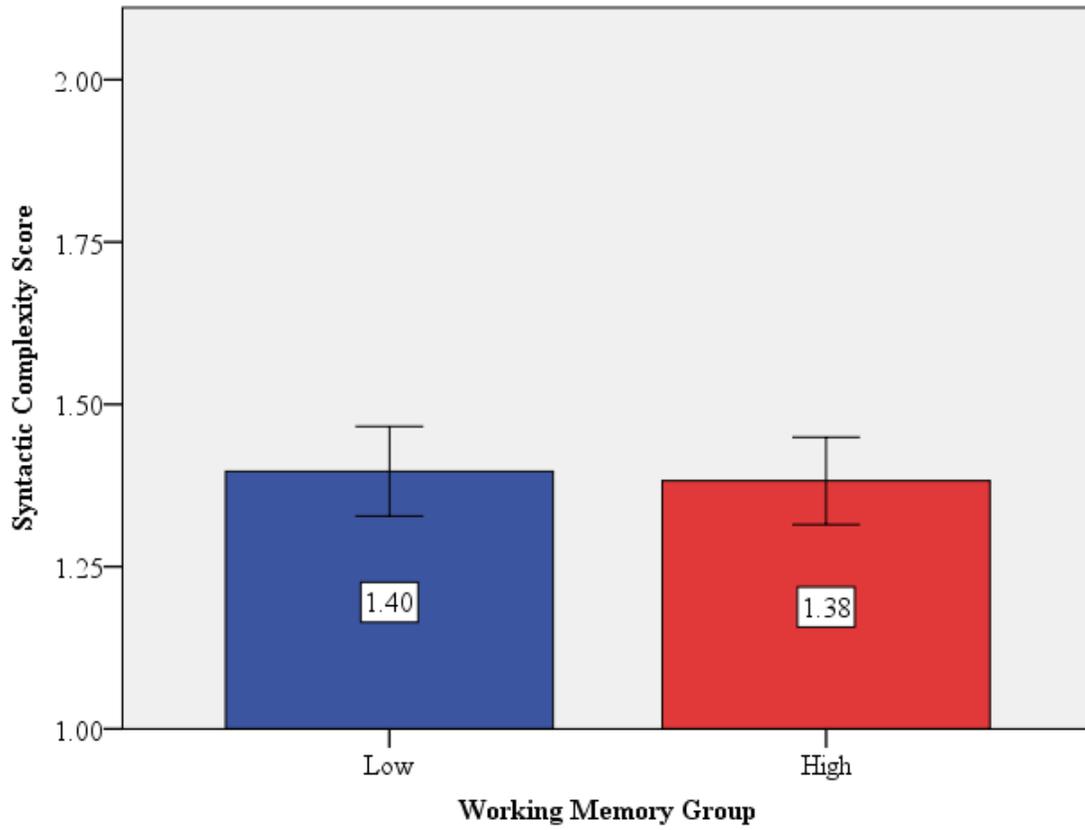
The purpose of this study was to investigate the influence of working memory and task type on the syntactic complexity of narrative discourse production in healthy aging adults. It was hypothesized that syntactic complexity would be significantly, positively related to working memory, regardless of age. Specifically, it was thought that low working memory scores would correlate with low syntactic complexity scores and high working memory scores would correlate with high syntactic complexity scores, regardless of the age of the participant. It was further postulated that the type of discourse task might mediate the cognitive-linguistic relationship between working memory and syntactic complexity. Specifically, that the degree of constraint and scaffolding inherent in the elicitation task might alter the cognitive and memory demands placed on the speaker, thereby influencing the level of syntactic complexity produced by participants.

The following discussion is organized to explore first, the relationship between syntactic complexity and working memory across task type, and second, to examine the role of age in the relationship between syntactic complexity and working memory.

Syntactic complexity and working memory, across task type

Results provided support for the hypothesis that the degree of constraint and scaffolding present in the elicitation task affects the nature of the relationship between working memory and syntactic complexity. Working memory group assignment (i.e. low versus high) and syntactic complexity scores were significantly related for only two of the four tasks: the single picture description and the story telling (see Figure 7). For the single picture description and storytelling tasks, participants in the high working memory group produced narratives with significantly greater syntactic complexity compared to

participants in the low working memory group; however, this relationship did not hold

true for the sequential picture description or the personal recount (see Table 4.1).

Findings also provide further evidence to other published studies suggesting that different

types of discourse tasks impose varying cognitive and linguistic demands on the speaker

(Caspari & Parkinson, 2000; Marini et al., 2005; Nippold et al., 2013; Youse & Coelho,

2005). To further investigate the influence of task type, a discussion of the results is

detailed in the context of each task.

        Syntactic complexity and working memory in picture descriptions. As

hypothesized, syntactic complexity was found to be significantly related to working

memory group assignment for the single picture description. Participants in the high

working memory group tended to have higher syntactic complexity scores and

participants in the low working memory group had lower syntactic complexity scores

(see Figure 1). However, the relationship between working memory and syntactic

complexity was not present for the sequential picture description task (see Figure 3). One

explanation for this difference is the degree of scaffolding present in the sequential versus

the single picture description. Specifically, the sequential picture stimulus presented a

series of pictures illustrating the order of events (Appendix C); whereas in the single

picture description, speakers had to infer the order of events to create a coherent and

logical story (Appendix B). As suggested by others, (Capilouto et al., 2005; de Lira et

al., 2011; Marini et al., 2005), the single picture description task is thought to be more

cognitively demanding for the speaker than the sequential picture description task.

Therefore, it may be that that the increased cognitive demands of a single picture

description illuminated the relationship between working memory and syntactic complexity in a way that the sequential picture description did not.

Syntactic complexity and working memory in storytelling. As with the picture description task, results indicated a significant relationship between working memory group assignment and syntactic complexity for the storytelling task. In support of the hypothesis that working memory capacity has a significant effect on the level of syntactic complexity produced, analysis indicated that participants in the high working memory group produced stories with greater syntactic complexity than participants in the low working memory group (Figure 4). The results reported here expand on the Kemper et al. (1990) study, which found a significant, positive correlation between performance on the backward digit span (Wechsler, 1958) and syntactic complexity scores on a storytelling task. The forwards and backwards digit span tasks were used to measure verbal working memory capacity in the Kemper et al. (1990) study. However since that time, the concept of working memory has evolved, as have the methods to measure working memory. Working memory is most commonly conceptualized as a *multi-component model* (Baddeley, 2003; Baddeley & Hitch, 1974) that divides working memory into subsystems, each of which has a limited capacity for storing and processing verbal or visual information (Appendix A). Accordingly, recent research has suggested that simple span tasks, such as the digit span, may not be accurate predictors of language performance as they assess only storage capacity and do not include a processing component (Caspari & Parkinson, 2000). In the current study, a working memory capacity score was derived from a more current and comprehensive set of complex span

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tasks modeled to assess the active maintenance of both verbal and visual information in the face of ongoing processing.

Syntactic complexity and working memory in recounts. In the current study, results failed to support the hypothesis of a significant relationship between syntactic complexity and working memory group assignment in the context of a personal recount (Figure 6). These results differ from the findings of Miller (2001), who reported a significant positive correlation between working memory capacity and syntactic complexity using a personal recount task. The contrast in findings may be attributable to differences in the nature of the personal recount elicited. For example, in the current study, the recount was elicited by prompting the participant to "tell me about your weekend." In the Miller (2001) study, recounts were elicited through a series of questions in the context of an interview, and so there was a greater likelihood that story elements such as setting, characters, problems and resolutions were elicited. The increased complexity of Miller's (2001) type of recount may place greater demands on the speakers working memory compared to the recount used in the present study. To further explore this idea, a random selection of personal recount language samples from the current study were examined. Post hoc analysis indicated that indeed many participants tended to simply list events that occurred over the weekend in more of a procedural manner rather than producing a recount with story-like elements.

To summarize the effects of task type, it is possible that, as suggested by Youse and Coelho (2005), the single picture description and storytelling tasks revealed relationships between working memory and syntactic complexity because of the high demands they placed on speakers' working memory. Youse and Coelho (2005) found a

significant correlation between a measure of working memory capacity, the digit span

task (Wechsler, 1945), and syntactic complexity for a story retelling task, but not for a

story generation task. The authors hypothesized that the story retelling task revealed a

relationship between working memory and syntactic complexity because it placed a

greater demand on working memory by requiring speakers to process information as well

temporarily store the information for the retelling. Similarly, in the single picture

description speakers must actively maintain the sequence of events in working memory,

without the scaffolding of sequential pictures, while performing the secondary processing

task of narrating a story. And in the storytelling task, speakers are challenged with

integrating both spatial and temporal components of the wordless picture book during

narration. Spatially, the pictures switch between two simultaneously occurring stories,

while temporally both stories progress from beginning to end (Appendix E). Therefore, to

convey the interplay between the two stories speakers must temporarily store information

from one story while producing an ongoing narrative. By contrast, the sequential picture

description and the recount allow speakers to simply list events in a sequential order

without having the high demands on working memory.

Syntactic complexity, working memory and the role of age

The second aim of the current study was to investigate to what extent age

influences the relationship between working memory and syntactic complexity. Working

memory is believed to be vulnerable to the effects of aging, which is supported by the

results of the current study (see Figure 9). It has been suggested that the linguistic

functions supported by working memory may also be affected. Specifically, it may be

that age-related declines in syntactic complexity are not due to language deficits, but

rather deficits in the underlying cognitive construct of working memory. Most evidence supporting the idea of a cognitive linguistic relationship between working memory and syntactic complexity is correlational in nature (Kemper et al., 1990; Miller, 2001; Youse & Coelho, 2005). Here, a two-way ANOVA was used to determine the main effects of two independent variables, age and working memory, on syntactic complexity produced during four separate discourse tasks. Analysis was designed to investigate if working memory capacity was related to syntactic complexity within each individual age cohort.

Based on results from previous studies (Kemper et al., 1990; Kemper & Sumner, 2001; Miller, 2001) it was hypothesized that, working memory would be significantly related to syntactic complexity for each discourse task even when considering the effects of age. For example, Miller (2001) found that working memory capacity and a syntactic complexity were significantly correlated across age cohorts (ages 25-85) and also held up for the young group (ages 25-35) individually. Interestingly, in the current study, results of the two-way ANOVA revealed a main effect of *cohort*, but not working memory, on the syntactic complexity of the single picture description and the storytelling task. In the remaining two tasks, the sequential picture description and the recount, neither cohort nor working memory had a significant main effect on syntactic complexity.

The main effect of cohort

Findings indicate that when the effects of cohort were statistically considered, working memory and syntactic complexity were no longer significantly related. Rather, it was the relationship between *cohort* and syntactic complexity that remained significant, regardless of working memory group assignment, for the single picture description and storytelling task (see Figure 3, see Figure 5). Post hoc analysis revealed a significant

decline in syntactic complexity with increasing age for the single picture description, sequential picture description and storytelling task. These findings add further evidence to the general consensus that syntactic complexity declines with age (Burke & Shafto, 2008); however findings do not support the hypothesis that a diminished working memory capacity is the cause of the decline (Kemper et al., 1990; Miller, 2001). While it is widely accepted that age-related declines in syntactic complexity occur, the age at which this decline begins is disputed. Studies by Kemper and her colleagues suggest that decline in syntactic complexity occurs primarily after seventy years of age (Kemper et al., 2001; Kynette & Kemper, 1986). In the present study, the age at which syntactic declines began varied by task type. The following sections detail age-related declines in syntactic complexity for each discourse task.

For the single picture description task, declines in syntactic complexity began with the older group of adults (ages 60-69); however, declines were not apparent until the elderly group (ages 75-89) for the sequential picture description task. Marini et al. (2005) did not find this difference between the single and sequential picture description; instead, for both types of stimuli declines in syntactic complexity began with the older group of adults (ages 60-74). The results of the present study also differ from the Cooper (1990) study which found no age-related declines in the syntactic complexity of a single picture description. The absence of age-related declines in syntactic complexity may be explained by differences in the ages of participants. Namely, Cooper (1990) did not include participants over the age of 79, whereas Marini et al. (2005) and the current study included adults up to the age of eighty-nine.

For the storytelling task, the decline in syntactic complexity was linear in nature, with the young cohort having significantly higher scores (M=1.64) than the older (M=1.45) and elderly groups (M=1.35) and the older group having significantly higher scores compared to the elderly group. Similarly, Kemper et al. (1990) found that the discourse of elderly adults was significantly less syntactically complex than the older olds. Interestingly, there were no significant age-related changes in syntactic complexity for the recount task. Results from the recount are in discord with the results of Miller (2001), who revealed significant age-related declines in syntactic complexity beginning with older adults, in their fifties and sixties. One possible explanation for the absence of age-related declines in syntactic complexity for the recount is the simplistic nature of the elicitation task. In addition to the recount task showing no evidence of age-related decline in syntactic complexity, it also had the lowest mean syntactic complexity score for any of the four discourse tasks administered, regardless of age (See Figure 8).

More recently, researchers and clinicians have proposed using an alternative type of recount, the peer-conflict-resolution (PCR), to elicit discourse (Nippold et al., 2013; Nippold, Mansfield, & Billow, 2007). In the PCR task, individuals are presented with a hypothetical scenario involving a conflict. Participants are then asked to retell the story and answer a series of critical thinking questions regarding the nature of the conflict and how one might handle and solve the conflict. In another less constrained version of the PCR task, participants tell about a problem or conflict they have had with someone else and how the problem was resolved. The increased complexity of the PCR task been suggested to elicit a discourse sample more reflective of the speaker's syntactic capabilities than a simple personal recount, as used in the present study. For example,

Nippold et al. (2013) analyzed the syntactic complexity of adults ages 20-69 using two types of discourse, a PCR task and a conversational task. Analysis revealed no age-related decline in syntactic complexity; but, participants, regardless of age, produced samples with greater syntactic complexity for the PCR task than the conversational task. It is important to note that while most evidence has found age-related changes in syntactic complexity beginning after 70 years of age, participants in the Nippold et al. (2013) study did not exceed age sixty-nine.

Study Limitations and Future Directions

Based on the findings of this study, follow-up studies should be conducted to further investigate how task type may mediate the relationship between age, working memory and syntactic complexity in healthy adults. One limitation to consider for the current study is the influence of psychosocial factors on communication performance (Arbuckle & Nohara-LeClair, 2000) and cognitive aging (Arbuckle, Maag, Pushkar, & Chaikelson, 1998; Stine-Morrow, Parisi, Morrow, Greene, & Park, 2007) . For example, when speakers describe a picture, tell a story, or relay previous experiences, the resulting narratives are certainly shaped by the speaker's life experiences and individual speaking style. Also, researchers have suggested that psychosocial factors such as occupation, social supports, and even physical activity may account for the individual differences observed in cognitive aging (Stine-Morrow et al., 2007). In line with this thinking, it has been proposed that age-related declines in syntactic complexity may be explained not by deficits in working memory, but by decreased exposure to syntactically complex language. Specifically, in attempt to facilitate understanding, adults are often spoken to in a syntactically simplified manner known as *elderspeak* (Burke & Shafto, 2008). While

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these psychosocial factors were not accounted for in the current study, future studies may consider collecting psychosocial information from participants to consider in analysis.

Recently, researchers have used controlled contexts to investigate working memory and syntactic complexity in healthy aging adults (Kemper, Herman, & Liu, 2004; Rabaglia & Salthouse, 2011). The use of controlled contexts attempts to eliminate cognitive and pragmatic influences which can make the results of naturalistic discourse difficult to interpret. For example, Kemper et al. (2004) asked young and older adults to produce a complete sentence from a presented list of sentence stems of differing syntactic complexity. Future studies might consider using both narrative discourse, as in the present study, and controlled language production tasks to investigate the relationship between syntactic complexity and working memory. Such an approach would allow for comparison between the levels of syntactic complexity individuals typically produce on a naturalistic task versus what they are capable of producing during a controlled context.

It is thought that high levels of education can act as a protective mechanism and reserve cognitive skills in the face of normal brain aging (Christensen, Anstey, Leach, & Mackinnon, 2008). In the same manner, education has been found to significantly influence discourse performance (Mackenzie, 2000; Youse, Stout, & Bosworth, 2001). Specifically, lower education levels have been associated with decreased use of embedded clauses (Kemper et al., 1989; Kemper et al., 1990). Participants in the present study were well-educated with an average level of 15.52 years of schooling. Therefore, future studies may recruit participants from differing educational backgrounds to consider how education might influence the production of syntactic complexity in adults across the lifespan.

Another limitation to the current study is that while both verbal and visual span tasks were used to measure working memory, it is possible that span tasks which overtly test language functions may be a more accurate indicator of how working memory affects the production of grammatically complex language in aging adults. An example of such a task is the reading span task (Daneman & Carpenter, 1980), which requires participants to read sentences aloud and remember the last word of each sentence. Additionally, instead of combining the scores of three different span tasks for the raw working memory score, it may have been beneficial to study each span task individually. Such an approach could help to better understand the ways in which specific components of working memory influence the production of syntactic complexity.

Clinical Importance

The current study has important clinical implications for the field of speech and language pathology as well as for future research on the cognitive and linguistic abilities of aging adults. Findings are relevant to the work of speech-language pathologists, as it is necessary to understand typical patterns of communication in healthy aging to appropriately diagnose communication deficits in pathological aging. Discourse analysis and cognitive testing are often included in the diagnostic battery for acquired communication disorders such as dementia, aphasia, and traumatic brain injury. Accordingly, knowledge of typical aging patterns of syntactic complexity and working memory can aid in the differential diagnosis of communication disorders. For example, recent research (Roark, Mitchell, & Hollingshead, 2007) has found success in using syntactic analysis to discriminate between healthy aging adults and adults with Mild Cognitive Impairments. While de Lira et al. (2011) has suggested that syntactic

simplification may be marker of pathological cognitive decline and help the early and differential diagnosis between Alzheimer's disease and normal age-related cognitive decline.

Results of the study also have important clinical implications for the use of discourse tasks in the treatment of adults with communication impairments. Speech-language pathologists commonly elicit narrative discourse using picture descriptions, storytelling, and recounts. However, results indicate that discourse tasks may not be interchangeable when assessing and treating syntactic deficits; instead, the relationships between age, syntactic complexity and working memory were mediated by task type. Findings of the current study provide evidence for which types of tasks to use during assessment and intervention of adults with deficits in syntactic complexity. For instance, rather than using a single picture stimulus as many standardized assessments do, a sequential picture stimulus may improve discourse performance for individuals with syntactic deficits. The series of pictures in the sequential picture stimulus provides increased scaffolding and is thought to reduce demands of working memory. Then, as treatment progresses and performance improves, the clinician may choose to use to a single picture stimulus, which provides less scaffolding and thus is more challenging for the speaker.

Finally and importantly, findings of the present investigation revealed that simple personal recounts, elicited by a statement such as "tell me about your weekend" are not ideal tasks to elicit a narrative discourse sample. The language samples produced from simple personal recounts were not reflective of the syntactic complexity participants were capable of producing and often elicited a procedural listing of events rather than a

narrative. Instead, clinicians should consider using tasks that require the speaker to reflect over more complex topics, such as the PCR task (Nippold et al., 2013), which has been shown to elicit more syntactically complex narratives for adults, regardless of age.

Conclusion

Results of this study support the general consensus that declines in both syntactic complexity and working memory capacity occur with healthy aging; therefore, changes in syntactic complexity and working memory with aging are not necessarily suggestive of pathological aging. However, findings provide limited support for the theory proposing that syntactic changes in late adulthood are driven by a decline in working memory capacity. Instead, the relationships between syntactic complexity, age and working memory were mediated by the type of discourse task. Specifically, the degree of scaffolding and complexity of the task influenced the effects of both age and working memory on syntactic complexity. In assessment and treatment, discourse tasks should be methodically chosen considering how the complexity of the task and degree of scaffolding will influence the level of syntactic complexity produced. In research studies investigating the relationship between age, working memory and syntactic complexity, results should be considered within the context of task type.

Figure 7

Mean syntactic complexity score by working memory group (low or high) for each discourse task
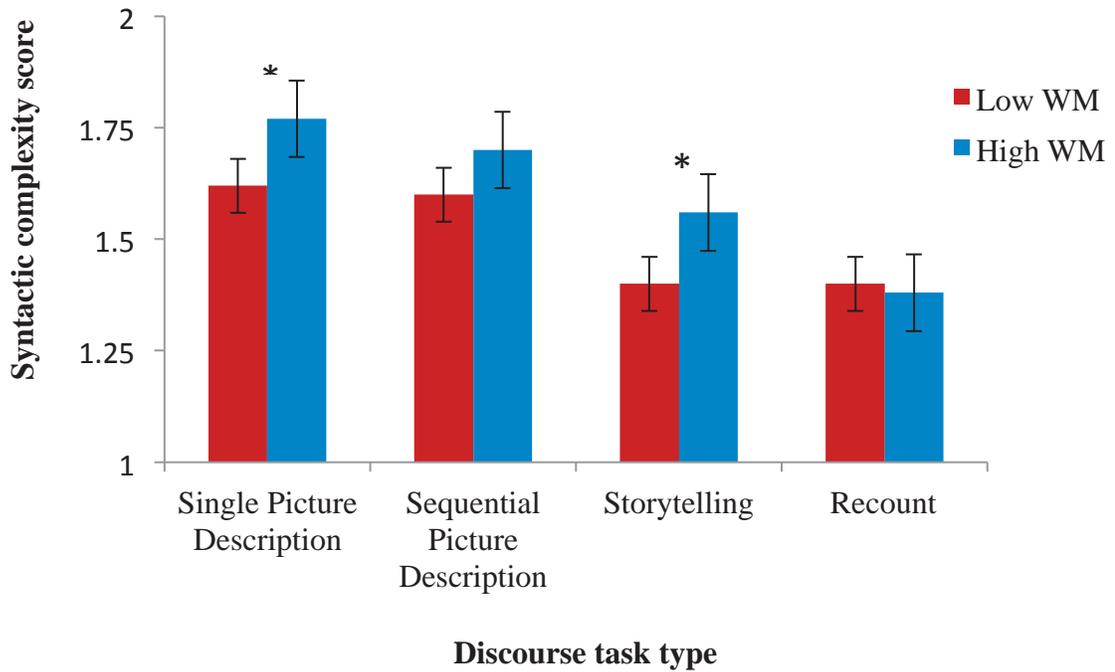
Low WM: Participants had a Raw Working Memory Score below the mean (*M*=25.17);

High WM: Participants had a Raw Working Memory Score above the mean (*M*=25.17)

Figure 8

Mean syntactic complexity score by cohort for each discourse task
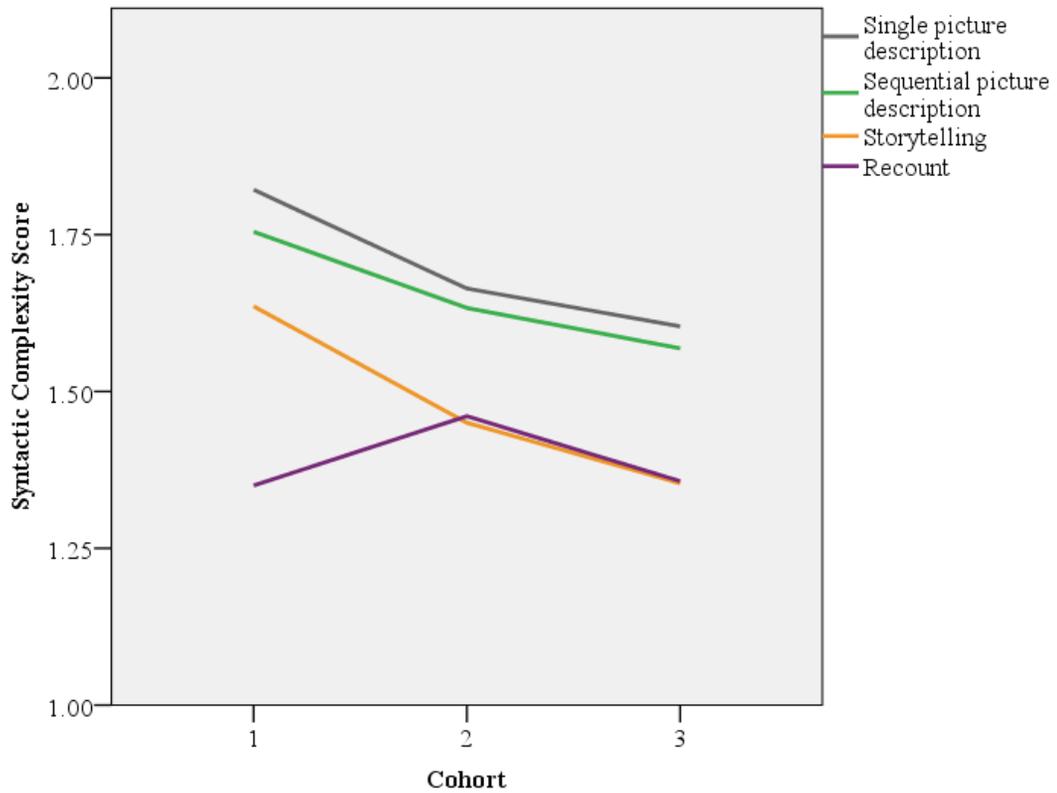
Cohort 1= Young Group (20-29 year olds); Cohort 2= Older Group (60-69 year olds);

Cohort 3=Elderly Group (75-89 year olds)

Figure 9

Raw working memory score[1] by cohort
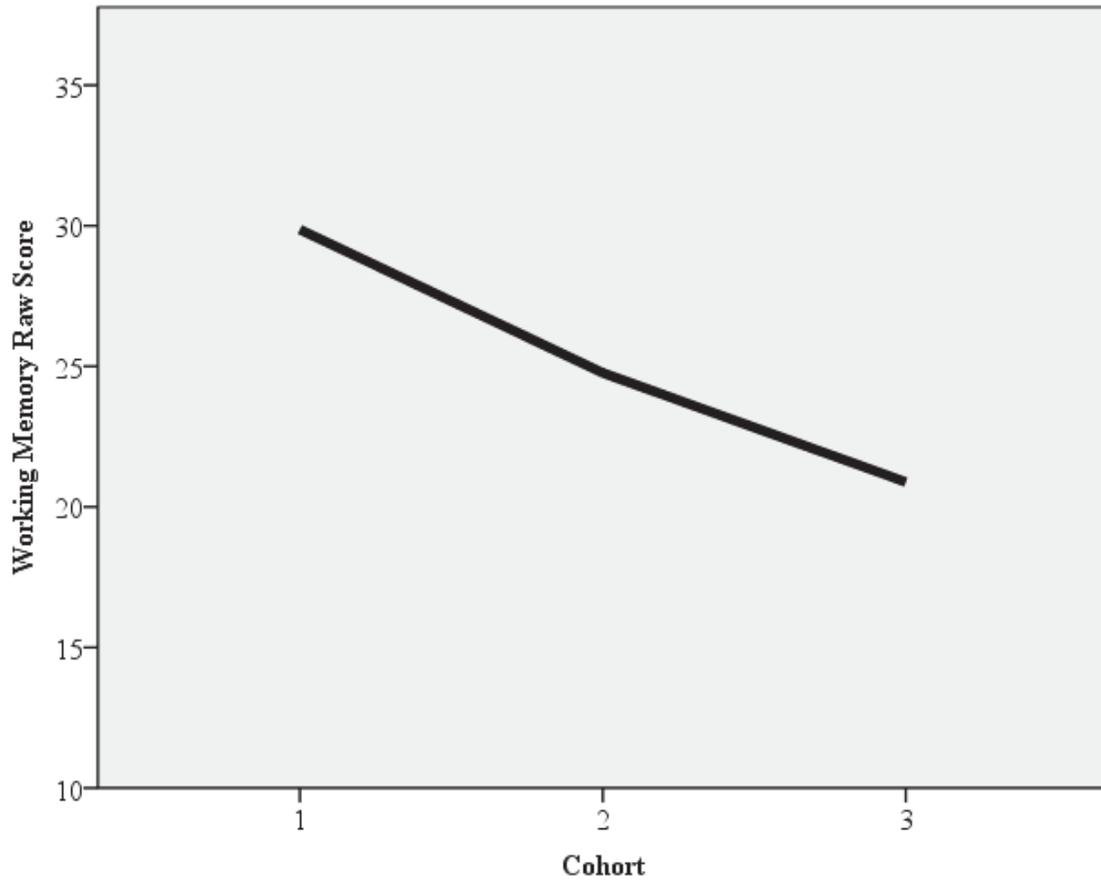
[1] Wechsler Memory Scale—Third Edition (WMS–III; Wechsler, 1997a);

Cohort 1= Young Group (20-29 year olds); Cohort 2= Older Group (60-69 year olds);

Cohort 3=Elderly Group (75-89 year olds)

Appendix A

Baddeley, A. (2010). Working memory. *Current Biology, 20*(4)

Appendix B

Cat in Tree Nicholas and Brookshire (1993)
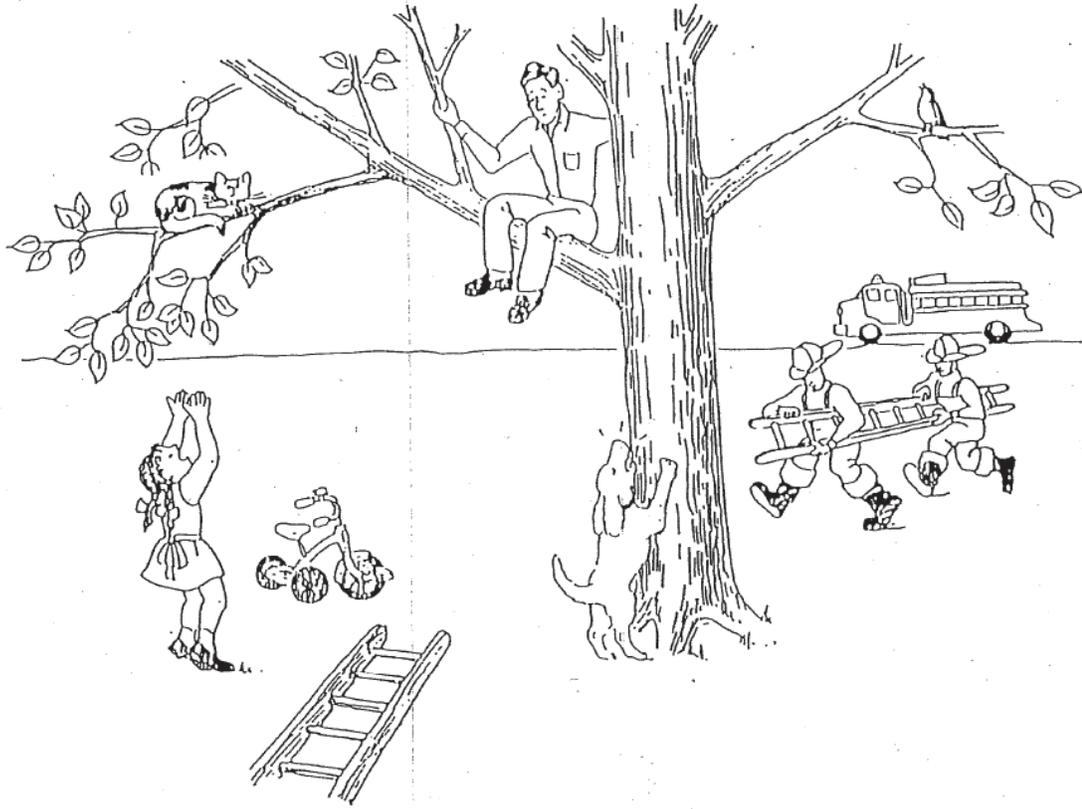
Appendix C

Directions Nicholas and Brookshire (1993)
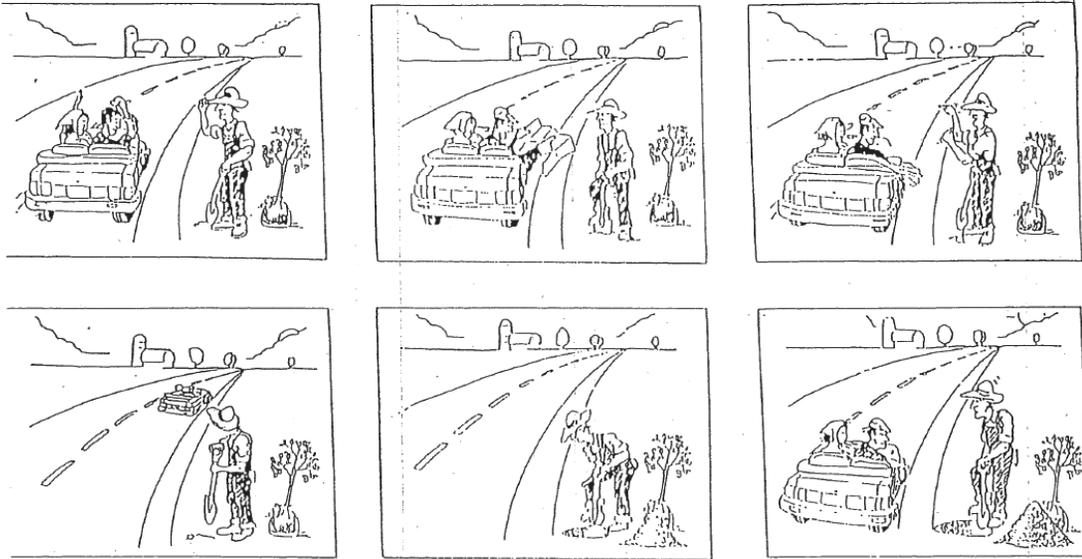
Appendix D

Cookie Theft (Goodglass & Kaplan, 1983)
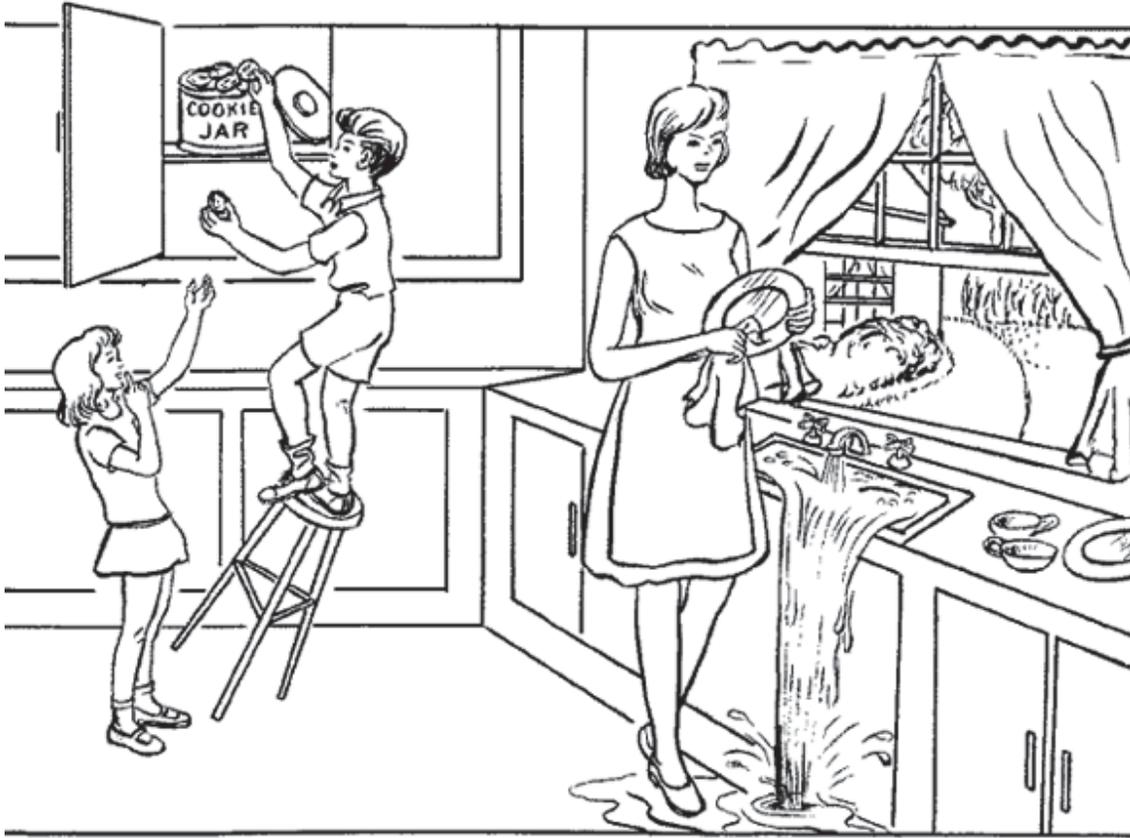
Appendix E

Story structure for Picnic (McCully, 1984). Taken from Wright et al. (2011)

Family of mice head off in their truck

↓

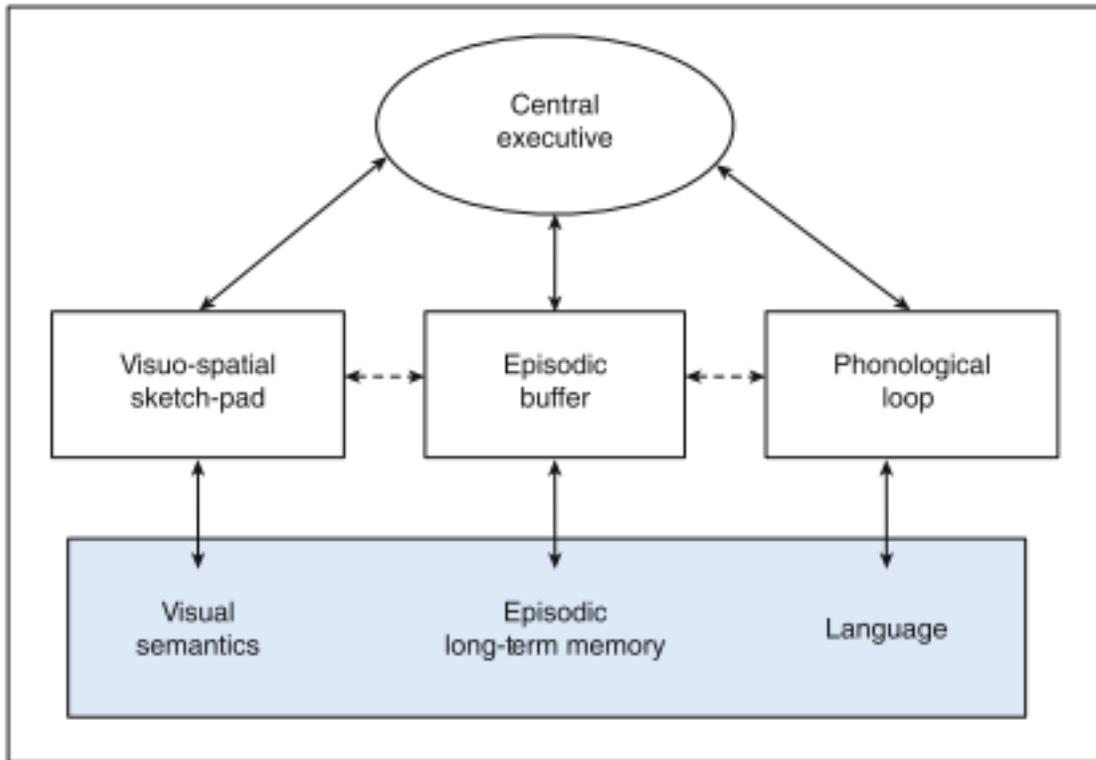| Truck hits a bump in the road, baby mouse falls out, no one notices |
| --- |

↓

Truck continues down the road

Baby mouse is all alone & sad		Mice arrive at the park, begin setting up for a picnic
↓		↓
Baby mouse holds stuffed animal		Mice play games & music
↓		↓
Baby mouse sees some berries/flowers		Mice eat, swim, take pictures
↓		↓
Baby mouse picks berries/flowers		Mice realize baby mouse is missing, start looking for him
↓		↓
		Mice are sad
↓		↓
Baby mouse lies in the grass		Mice head to the truck
↓		↓
Baby mouse walks around		Mice in truck driving down the road

↓

Baby mouse runs out in the road, sees the truck, sees mice & they reunite

↓

Baby mouse misses his stuffed animal

↓

Baby mouse goes back into the grass and finds his stuffed animal

↓

The mice family reunite and have the picnic on the side of the road

Appendix F.

Script for Storytelling Task Example.

"These are children's books without words- so that a person can make up their own story. First I will look through the book and get an idea of the story. Then, I will start at the beginning and tell you the story that goes with the pictures"

The examiner read the following scripted story with each new line indicating a page turn:
"A ship captain and his first mate have cited something in the water. A father and daughter are also on board the ship.
The crew along with the father and little girl left the ship in a small boat and traveled to an island they spotted. Now they are on foot and have a great deal of camera equipment with them. They come across a group of natives watching a turtle race.
The captain taps one of the natives on the shoulder and asks a question. The native points to the top of a mountain. The crew begins to climb the mountain. They climb and climb until the captain calls out to them as he points to something in the distance. He is pointing to a great ape swinging on a swing that is held up by a huge tree between two mountains. The crew begins to climb the mountain looking at the ape and the ape looks back in time to see the little girl fall- the ape catches her. He smiles at her and puts her on top of his head-And starts to swing some more. The crew opens a chest they have been carrying and put out a pump and something else-Oh it is a giant banana. They blow it up. The ape reaches for it.
The crew starts to run down the mountain with the banana hoping the ape will follow them-
And he does. He follows them into the water as they head back to their ship. Once they get to the ship- the ape gets the banana and turns to look at it- when he does he accidentally sits on the ship and the little girl falls off his head into a ship mate's arms.
The ape continues back to shore pleased with his banana. He stops about half way back and feels the top of his head. He realized that the little girl is gone and he is sad.
The little girl is on the deck of the ship- waving goodbye to the ape and crying.
The ship enters New York Harbor.
The father takes a picture of the little girl with the Empire State Building in the background.
Meanwhile, the ape is in the mountains looking very sad.
A plane flies over his head and drops something out- he catches it.
It is the picture of the little girl! The ape is very happy and hugs the picture.
The End."

Appendix G

Calculated Complexity Index of single picture description task, 'Cat in the Tree.'

Transcript from female in young cohort (ages 20-29).

@G:	Cat	IC	DC
	20_10_G		
1	um little Susie was riding her tricycle on Saturday afternoon and jus(t) riding around having a good time playing with her.	1	
2	and her little kitten was outside too.	1	
3	and she was playing with it when all of a sudden the neighbor's dog got out and started barking and running at her kittens.	1	1
4	so she ran and tried to tried to get it before the dog got to it.	1	2
5	but before she could her kitten ran up the tree and went all the way out on a tree limb.	1	1
6	so she ran inside crying to get her father who came out and tried to climb up the tree to get to help her kitten.	1	4
7	meanwhile her mother was smarter.	1	
8	and she called the fire department.	1	
9	um so the fire department rushes there as her father's trying to get out on the limb to get the kitten.	1	3
10	and then in the end the firemen get up and help the father down and save the kitten.	1	
		10	11
			2.1

Calculated Complexity Index of personal recount task, weekend. Transcript from male in

older cohort (ages 60-69).

@G:	Weekend	IC	DC
	60_18_G		
1	my last weekend was spent in Pittsburgh Pennsylvania.	1	
2	uh we had to make an emergency trip there because my daughter delivered uh thirteen weeks early.	1	2
3	uh a premature boy weighed one pound eleven ounces.	1	
4	uh we obviously we left Lexington at seven in the evening and got to Pittsburgh at three o'clock in the morning uh spent the weekend at the hospital uh with the nurses the doctors.	1	
5	and everything's goin(g) great.	1	
6	I returned uh on Wednesday.	1	
7	I left my wife up there to help my daughter.	1	1
		7	3
			1.428571429

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