VERBAL CREATIVE PROCESSING IN YOUNG AND OLDER ADULTS

By

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In memory of my father, James P. Bledsoe, Ph.D.
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The purpose of this study was to investigate creative verbal processing and assess how those processes were affected by healthy aging. It has been suggested that there are a number of processes involved in creative processing; these include divergent processing, convergent processing and associative processing. The processes are thought to rely on, or use similar resources to, different forms of cognitive processing. Divergent processing is thought to rely heavily on frontal functions such as disengagement, convergent processing on domain-specific knowledge and associative processing is thought to rely on knowledge of semantic relationships. Changes in brain structure and function occur with normal aging and while some elements of verbal creative processing may be negatively affected by these changes, other elements may remain unchanged or even improve in older adults. The participants used in this study consisted of thirty older adults and thirty younger adults. Testing consisted of a series of standard language and cognitive measures as well as a battery of tasks designed to assess the elements of verbal creative processing individually as well as in a creative production task. The creative production task required participants to make up short stories using sets of three semantically unrelated words. Results showed that older

adults produced significantly more unique words that were not produced by any other participant in divergent processing tasks, and were significantly better on one of two convergent processing tasks. However, scores from independent ratings of stories showed that older adults performed significantly more poorly than younger adults at producing stories that were judged to be unique or original. We propose that the difference in findings is due to the ability to use previous knowledge or experience to produce unique responses on the divergent tasks, while the creative production task required the formation of novel semantic associations.

CHAPTER 1
INTRODUCTION

In this study we propose to compare young and older adults' performance on a battery of tasks of creative verbal processing to learn which elements of verbal creativity are most affected by normal aging. Some elements of creative processing have been shown to be affected by normal aging (e.g., divergent processing as shown by McCrae, Arenberg, & Costa (1987)), but other elements have not yet been examined in healthy aging adults. Most testing of creativity and aging to this point have focused on nonverbal, spatial creativity tasks and these have shown some decrement with increasing age. However, spatial abilities are more dependent upon right hemisphere processes which have also been shown to suffer more than left hemisphere processes with aging. Since language ability is thought to depend more heavily on left hemisphere processes, it is unknown how verbal linguistic creativity will be affected by aging.

The ability to use language, and therefore the ability to use language creatively is dependent upon millions of neural interconnections that form networks in the brain. Beginning in childhood we build a store of semantic representations for the objects and ideas in the world around us. For any object or concept we create a network that contains information about how that object looks, smells, and tastes. We store information about how that object makes us feel (for example, a snake may be frightening) and information about experiences we have had with the object. We also store the way the word that represents that object sounds when we hear it (i.e., phonological lexical representation), what movements we must make to say it ourselves (i.e., phonetic representation), and which letters are used to represent it (i.e., orthographic lexical representation). These networks of information are known as semantic memories and it is access and manipulation of these representations as well as our knowledge of how language is structured (i.e., syntax) that is the basis for human's linguistic ability.

The creative use of language depends upon the capacity to employ different forms of cognitive processing. These include divergent processing, which is the ability to produce a broad range of responses and convergent processing, the ability to produce the one correct response. Associative processing is also important and involves the ability to see connections between concepts. Associations may be previously learned or be completely novel. It is known that some cognitive processes are affected by normal aging as are some language functions. Cognitively, older adults have been shown to be more prone to "rigidity", that is, they are more likely to produce responses from a single set (even when changing the set is indicated), and more likely to produce perseverative responses (i.e., responses that have already been produced) (Craik, Morris, Morris, & Loewen, 1990). These deficits indicate a decrement in flexibility of thought, a capacity intrinsic to divergent processing. In the area of linguistic ability, older adults have both strengths and weaknesses. Older adults have been shown to have more difficulty naming objects (Bowles & Poon, 1985) a task that requires convergent processing as well as access to stored semantic and lexical representations. On the other hand, they have been shown to generate richer narrative samples in some situations (James, Burke, Austin, & Hulme, 1998; Pratt & Robbins, 1991) and to have larger and more varied vocabularies (Verhaeghen, 2003), indicating a greater number of stored semantic representations. These are factors that could affect older adults' ability to use language creatively both negatively and positively.

Creativity, the production of novel and innovative ideas, in general requires the manipulation of stored knowledge; verbal linguistic creativity requires the manipulation of stored lexical-semantic representations. As indicated by previous work on cognitive rigidity and normal aging, it may be that older adults will have more difficulty in redefining the scope of representations as well as in making new connections or associations between previously unrelated concepts/representations. Creativity involves not only cognitive processes, but also motivation, and personality traits (Richards, Kinney, Lunde, Benet, & Merzel, 1988). However, motivation and personality traits will not be addressed in this study so that we can focus on the cognitive processes in more detail.

CHAPTER 2
REVIEW OF THE LITERATURE

Creativity

What is creativity? Creativity has been defined as the ability to understand, develop and systematically express novel orderly relationships (Heilman, 2005). Behavior is called creative if it results in a product that is novel, original, surprising, and unique (Eysenck, 1995). However, in order for a product (i.e., a novel, a painting, an invention) to be considered creative, it also must be appropriate. Unusual and surprising behavior and cognition are often encountered in mental disorders such as schizophrenia, however, the behavior of these individuals is not usually thought of as creative since it is often not appropriate. Distinctions have been made in the history of research investigating creativity between creative persons (e.g., Picasso, Mozart), creative products (e.g., paintings, novels, scientific innovations), creative processes (e.g., divergent processing, flexibility of thought), and creative environments. This study focuses on creative processes and specifically how aging may affect these processes. Creativity processing requires several types of thinking, as well as a certain amount of knowledge in an area. For instance, an artist is not able to paint a masterwork before learning the basic skills of painting.

Theories of Creativity

There have been many theories of creativity proposed in the last 100 years. They have focused on different aspects of creativity including psychometric approaches (i.e., how to measure creativity) such those proposed by Guilford (1950) and Torrance (1974). An associative model of creativity has also been developed (Mednick, 1962) as well as a theory of creativity based on investment perspectives (Sternberg & Lubart, 1995). There have also been theories based on biological bases of creativity.

For at least the last hundred years, researchers have tried to understand what enables the brain to be able to make the intuitive leaps necessary for creative production. One aspect that has been explored in some detail is cortical arousal. Cortical arousal can be considered as a continuum, ranging from deep sleep all the way to extreme tension or anxiety. Arousal has been shown to be related to learning and performance in that both are at optimal levels near the middle of the arousal continuum (Hebb, 1955). Task complexity influences where on the continuum optimum performance occurs. Simpler tasks are performed better at higher levels of arousal, while more complex tasks are performed better at lower levels. The reason for this difference in optimum arousal levels for task complexity lies in the type of response that is most likely to be produced at different arousal levels. With high levels of cortical arousal, responses are more likely to be highly frequent, stereotypical responses, which is optimal for most simple tasks. However, with low levels of arousal it is more likely to produce non-dominant or unusual responses which are often better suited to solving more complex problems (Martindale, 1990; Simonton, 1980).

There have been examples throughout history of scientists being able to suddenly solve a difficult problem when they relaxed and turned their attention away from the problem at hand. This sudden ability to solve a difficult problem when in a state of relative relaxation is due to the reduced level of cortical activation. High levels of cortical arousal are brought on by stress or anxiety, and it has been suggested that it is in this state of high arousal that we more often make conscious attempts at problem solving but may be unable to produce a viable solution (Eysenck, 1995). Arousal may be increased by a number of factors including stress, noise, temperature extremes, reward, even the presence of others, and all of these factors have been shown to lower creativity (reviewed in Eysenck, 1995). Another possible mechanism behind the ability to make the unusual connections associated with creative thought is a reduction in cognitive inhibition. This theory has centered on research done on individuals with schizophrenia as well self-reported traits of highly creative individuals.

Elements of Creative Processing

At least four necessary elements of creative processing have been identified in the literature. These include domain specific knowledge (Weisberg, 1999), divergent and convergent processing (Guilford, 1950), and associative processing (Heilman, 2005; Mednick, 1962). A brief explanation of these elements and how they contribute to creative processing are provided in turn.

Domain specific knowledge

In order to be creative in a domain, an individual must have some base of knowledge to work from (Weisberg, 1999). It has been shown that creative thinking builds on knowledge, and that highly creative people have acquired an extensive amount of experience in their chosen field (Weisberg, 1999). This background knowledge is often referred to as domain specific knowledge, and in the case of verbal creativity, the domain specific knowledge required is language. Fortunately, most adult humans are very proficient in using language, although vocabulary levels and grammatical knowledge can vary according to education and experience.

Divergent processing

Divergent processing is the second critical element. Guilford (1950) proposed the importance of this type of thinking to the process of creativity. Divergent processing involves the ability to activate a broad array of novel acceptable responses or solutions to given stimuli. Divergent processing requires disengagement, the ability to switch to a new set or interpretation, as well as the production of alternate responses. A test often used to assess Divergent processing in school age children is the Torrance Test of Creative Thinking (TTCT) (Torrance, 1974). This test consists of both figural and verbal prompts designed to elicit an array of responses. Unusual uses, also known as Alternate Uses, (Guilford, Christensen, Merrifield & Wilson, 1978) is also commonly used to assess Divergent processing as are verbal fluency tasks, wherein respondents are asked to produce words as quickly and fluently as possible.

Convergent processing

The term “convergent processing” was also coined by Guilford (1950) and it stands in opposition to divergent processing. Rather than producing a wide range of answers, the goal in convergent processing is to produce the one correct response or the best solution to a given problem. Convergent processing requires the ability to synthesize concepts or put ideas together in a structured way. It emphasizes logic, accuracy, and recognition of the familiar. When Guilford first introduced this term, it was thought of as the antithesis of creative thought. However, it was eventually recognized that it is also necessary to be able to evaluate the ideas generated in divergent processing and recognize which may be most tenable (Cropley, 2006). As mentioned earlier, a truly creative product is not just innovative, it must also be appropriate.

Convergent processing has been linked to knowledge since it often involves manipulation of previously acquired information (Cropley, 2006). Convergent processing, when focused on finding similarity or commonality in what appear be unrelated words or concepts, is dependent on knowledge of semantic relationships. The commonality between two concepts in any given instance may be previously learned (e.g., tigers and lions are similar in that they are both cats) or novel. When relationships are previously learned, making the connection is dependent simply on recalling pre-existing knowledge. However, when relationships have not been learned, but need to be formulated, the semantic representations need to be manipulated to discover how they fit together.

Associative processing

Associative processing involves activating all the concepts or ideas that are related in any way to another given concept or idea. Associative processing can be used divergently or convergently. It may be that for creative production, it is the connections that are available between semantic representations that are more important than the number of semantic representations. Associative Fluency is an example of an associative divergent task. The task requires respondents to generate all the words they can think of that are associated with a target word. Word association tasks can also require convergent processing, such as is used in the Remote Associates Test (RAT) (Mednick, 1962). The RAT provides three words and asks the respondent to provide a fourth associated word that links them all together. An example of this would be the provision of the words “monkey, bite and widow” with the linking word SPIDER.

Creative Language Use

Creativity is often assumed to be the province of a few “creative geniuses” such as Einstein or Picasso. In fact, most of us are involved in some type of creative generativity every day through the production of language. One of the fundamental aspects of human language is its creative nature. An adult human being has the capacity to produce and understand an infinite variety of sentences.

Noam Chomsky (1972) famously stated that all language use is creative – meaning most propositional sentences uttered in a given day have not been uttered before in exactly that form. We do not have exactly the same experiences or interactions each day, nor the same thoughts or emotions about those experiences. Consequently we are required each day to express novel thoughts or describe novel experiences using language. We have to pick the right words to express the nuances of the given experience, or perhaps compare the experience or thought to another to make it better understood by the listener.

These comparisons of two objects or concepts are often made in everyday language through the use of analogies or similes which are both examples of the inherent ability of language to express novel associations. Associating between concepts to form new mental connections or to understand connections requires divergent processing. This is why the ability to produce unusual associates for given words has often been used as a measure of creative ability. Mednick (1962) described the concept of an associative gradient. An associative gradient ranks the frequency that certain words are produced as an associate response to another word. For example, if asked to give an associated word for “table”, the words “cloth” or “chair” would be frequent responses, whereas “plains” (which are flat like a table) would be a less common associate. If a given individual responds to a provided word with mostly high frequency responses from the same or similar semantic categories, it results in a steep associative gradient. In contrast, if an individual responds with more infrequent associates from disparate semantic categories, the result is a flatter associative gradient. The steepness of the associative gradient of an individual has been found to be highly correlated with rated or demonstrated creativity (MacKinnon, 1962). A flat gradient is a sign that the individual is able to associate more freely between categories and is able to depart from habitual thinking patterns and see alternative connections.

Creativity and Aging

Creativity has been associated with properties such as flexibility, openness, autonomy and humor; these same properties are also associated with a “healthy personality (Cropley, 2006). Unfortunately, creativity has also been reported and is popularly believed to decline with advancing age. Studies examining the production of creative products both in artistic and scientific realms have reported that creative productivity usually peaks in the twenties or thirties and drops off after the forties (Lehman, 1953, Simonton, 1988).

One of the determining factors that might influence the relationship between creativity and age is how long a person lives, their life-span. Some of the individuals examined in these studies may have died at a relatively young age. If they had lived longer, perhaps they would have produced more works in their later years. In fact, Lindauer (1993) reported that if you examine only the longer lived individuals in these studies, the peak of creative production appears to be in the fifties. Another issue is individual variability, there are numerous examples of great creative products being produced by people who are in their ninth decade. Another issue concerns the focus of the study on major creative products. There is a difference between major creativity (such as works produced by Mozart) and the more humble everyday type of creativity.

Cropley (2006) reports that creativity and mental health are linked, at least at the level of everyday creativity. Studies have linked creativity with mental flexibility and adaptability; abilities that many theories of successful aging say are crucial (Flood & Phillips, 2007). Practicing creativity has been shown to be beneficial to older adults; there is a positive relationship between creativity and mental well-being, health, and life satisfaction (Fisher & Specht, 1999; Hickson & Housely, 1997). It has been shown that engaging in everyday creative activities such as writing poetry or journals (or painting, acting, etc.) can improve mental health outcomes in areas such as self-esteem, coping skills, anxiety level, life satisfaction, and depressive symptoms (Flood & Phillips, 2007).

While the benefits of creativity have been explored, there has been relatively little exploration of how everyday creativity might be affected by aging. As mentioned earlier, we know that there are factors that may impact creativity positively and negatively in normal aging. Since it has also been shown that creative thinking abilities can be stimulated and nourished through education and training in older adults (Flood & Phillips, 2007) it is important to know what strengths or weaknesses might be present. A greater understanding of what might inhibit creativity in older adults could be an invaluable resource for designing training programs that foster creative thought. However, in order to understand how creative processing may change with aging, it is crucial to understand how the brain itself changes with aging.

Changes in Structure of the Brain with Normal Aging

The brain is a changing entity. From birth through young adulthood and into old age, our brains go through a number of changes. In early life we acquire a large number of connections between neurons, some of which are kept and others allowed to decay. It was formerly believed that once we reached adulthood our brains were no longer capable of changing. We know now that the brain is always capable of change in terms of forming new connections (i.e., learning) although the ease and speed of this process varies with age. Unfortunately, there are also changes that occur with normal aging that are not so positive. Overall, the brain decreases in size and weight (Berg, 1948). There is a small loss of neurons, about 10 percent of the total, particularly in supramodal association cortices such as the dorsolateral frontal lobe and the inferior parietal lobe (Pakkenberg, et al., 2003). Research has also shown that the frontal lobes are affected by normal aging; in fact, age-related decline is more evident in frontal lobes than in any other cortical area (Bryan & Luszcz, 2000). In a recent longitudinal study involving successive MRI images over 4 years on healthy older adults, it was found that the frontal lobes showed the steepest rate of atrophy (Resnick, et al., 2003). In addition, even without the presence of disease processes such as seen in dementia, amyloid plaques, neurofibrillary tangles, and a loss of dendritic branching may all be observed in the brains of healthy older adults.

Another aspect of brain structure that is affected by aging is interneural connectivity**.** There are two major components of the human central nervous system, the gray matter which is made up mainly of neuronal cell bodies (i.e., the cortex) and the white matter which is made up of the myelinated axons of these cells. There is some local synaptic communication between neurons at the level of the cortex (i.e., gray matter), but most long distance communication between neurons occurs in the white matter connections. White matter connections carry information between neural cells interhemispherically as well intrahemispherically (e.g., via the corpus collosum).

As mentioned earlier, there is some loss of gray matter (or neuron bodies) with aging. However, this loss is not as substantial as the loss of white matter. Most of the volume and weight loss seen in the elderly brain is through the loss of white matter and subcortical neuronal loss (Guttmann et al., 1998). White matter loss has been found to start at a later age than gray matter loss (40 versus about 20, respectively) (Ge, Grossman, Babb, Rabin, Mannon, & Kolson, 2002), however, once the loss of white matter begins in midlife, it is more rapid than the atrophy seen in gray matter. The signal properties of white matter in normal aging have also been investigated using magnetic resonance imaging (MRI) as they reflect possible changes in myelination which impacts transmission of information between neuronal cells and networks. Signal intensities implying changes in white matter connectivity have been shown in nondemented older adults (Davatzikos & Resnick, 2002).

Connectivity has also been investigated using diffusion tensor imaging (DTI) which allows direct measurement of white matter microstructure (Pfefferbaum et al., 2000). Since white matter is organized in fiber bundles, which restricts the motion of its water particles, it is considered to be anisotropic since the amount of possible diffusion is constrained. DTI can be used to measure the amount of anisotropy in white matter, and several recent studies have investigated this in normally aging brains (Pfefferbaum et al, 2000; Sullivan et al., 2001). These studies have shown a significant decrease in anisotropy in white matter fibers, particularly in the corpus collosum. This decrease indicates a breakdown in the integrity of the white matter microstructure (Pfefferbaum et al., 2000).

Changes in Functions of the Brain with Normal Aging

Frontal lobe function

Areas of the frontal lobe are responsible for what is often referred to as "executive functions." Executive functions are cognitive processes that control and integrate other cognitive activities, thereby allowing an individual to engage in independent goal-directed behavior. Planning, internal ordering, monitoring, regulating, and motivating have all been attributed to prefrontal cortex. Executive functioning involves the ability to conceptualize a plan of action, to order and maintain a plan of action, to inhibit unwanted behavior, and to assess the ongoing plan and modify if necessary.

Commonly observed differences in cognitive and memory performance in older adults may be based in declines in executive functioning processes (e.g., a decline in the ability to inhibit irrelevant information as suggested by Hasher et al. (2001)). However, age related decline is milder than what is seen in executive dysfunction following frontal lobe damage (Bryan & Luszcz, 2000) and as such may be harder to detect using standardized tests that have were developed for use with brain damaged populations. Executive function tasks may also be stressful and unpleasant for older adults, particularly tasks such as the Wisconsin Card Sorting Task (WCST) which is ambiguous and whose rules change with no warning (Bryan & Luszcz, 2000).

A common deficit seen when testing executive processing in older adults is perseveration. Perseveration is the repetition of a previous response when presented with new stimuli, and is thought to result from an inability to switch the set of responding, a state known also known as "stuck-in-set". This may occur when a task requires switching fluidly between one or more sets of responses as has been shown on studies examining older adults' performance on the WCST (Craik et al., 1990). The STROOP test (Ridely, 1935) wherein respondents are asked to read the names of color words printed in a contrasting color to the name, is also used to assess ability to disengage from a previous response or from a prepotent response.

Another method commonly used to assess executive functioning is fluency tasks. Fluency tasks may be verbal or nonverbal and require the respondent to generate unique exemplars quickly. Verbal fluency tasks are an indication of an individual's speed and ease of access to stored lexical semantic representations, and also measure initiation (how quickly an individual can respond to the request to generate). Successful performance on fluency tasks is thought to rely on strategic search processes, and the use of strategies reflects executive processing (Bryan & Luszcz, 2000). A widely used verbal fluency task is the Controlled Word Association (COWA) (Benton & Hamsher, 1976). The COWA requires the respondent to generate words beginning with specific letters (e.g., "F, A, S", often called the FAS test for this reason), but not to use proper names or derivatives of previously used words. Performance on this task is measured by tallying the total number of acceptable words, number of perseverations, and number of responses that break rules (i.e., proper names or derivatives of previous responses). This type of task is also known as letter or phonemic fluency.

There are few if any cognitive activities that do not involve some level of activity in the frontal, parietal and temporal lobes. When someone speaks about a frontal lobe function, they are referring to the specific role that the frontal lobes are contributing to this cognitive activity. For example, the COWA is often used clinically to learn if a patient has a defect in their left frontal lobe (Lezak, 1995). It is likely that a person who had suffered great damage to the temporal and your parietal lobes would not perform well on this task. However, if you demonstrate that the critical functions mediated by the parietal and temporal lobes are intact (e.g., naming is normal) and a person still performs poorly on the COWA, then it is an indication of frontal dysfunction.

Phonemic fluency is known to be sensitive to frontal lobe damage. However, this test may not be as sensitive to declines in frontal lobe functions seen in normal aging. Only small differences have been found, indicating that phonemic fluency is maintained relatively well in normal aging (Bryan & Luszcz, 2000). Phillips (1997) suggested that the phonemic fluency task is not novel enough, that older adults may be aided in their performance on this task by experience with similar strategies used in completing crossword puzzles or other word games. In contrast, age-related declines have been reported in normally aging adults in categorical, or semantic, fluency tasks (Kozora & Cullum, 1995; Troyer, Moscovitch, & Winocur, 1997). Semantic fluency requires the respondent to generate words within a category; the category of animals is commonly used. Design fluency is a nonverbal task that requires respondents to generate as many designs as possible within a time limit. It has also not been shown to be very sensitive to age differences (Bryan & Luszcz, 2000).

It has also been shown that older adults have a greater decline in “fluid” intelligence measures than in “crystallized” intelligence measures. Crystallized intelligence is the knowledge and skills obtained over a lifetime of learning and experience. Crystallized intelligence can continue to increase during a person’s life as they continue to learn and experience. For example, vocabulary knowledge is known to increase with age (Verhaeghen, 2003). Fluid intelligence, on the other hand, involves problem solving, pattern recognition and the ability to manipulate information. A test commonly used to assess fluid intelligence is the performance measures of the Wechsler Adult Intelligence Scale (WAIS) including picture completion and picture arrangement tasks. These fluid intelligence measures show more of a decline with aging than do the measures assessing crystallized intelligence (Ryan, Sattler, & Lopez, 2000).

Is divergent processing dependent upon the frontal lobes?

Lesion studies as well as functional imaging studies suggest that the frontal lobes are important for divergent processing (Damasio & Anderson, 2003). Divergent processing requires two components, disengagement and the formulation of alternate responses or solutions. Disengagement requires the ability to switch sets, to shift from a response set that has not been fruitful, or is no longer as fruitful, to an alternate response set, or to disengage from a more common interpretation of a response. The WCST (Craik et al., 1990) is a commonly used assessment of disengagement, and regional blood flow studies have shown increased blood flow in the frontal lobe when normal subjects are given this test (Weinberger, Berman, & Zec, 1986). The second component of divergent processing is the production of alternate responses. Neuroimaging studies suggest that the frontal lobes are also crucially involved in this step; when researchers compared individuals who had scored either high or low on creative indexes, the highly creative individuals were shown to have greater frontal activation when asked to provide alternate uses for a common object than were the individuals with low creativity (Carlsson, Wendt, Risberg, 2000).

The Unusual Uses test (Guilford, 1978) been also used to assess Divergent processing in individuals with frontal lobe injuries. This task is from a battery of measures of creativity created by Guilford (Guilford et al., 1978). This task is assumed to test flexibility of thought and creativity (Lezak, 1995). Respondents are asked to name all the alternate uses they can think of for a common object. Butler, Rorsman, Hill & Tuma (1993) used this task to assess individuals with frontal lobe tumors and found this task to be more sensitive to frontal lobe dysfunction than COWA. They suggested that the Unusual Uses task may involve more complex fluency processes since it requires the respondent to access associations between semantic representations. Bryan & Luszcz (2000) also reported a greater correlation between advancing age and the Uses tests than between age and phonemic fluency. They also report that differences in this task have not been widely examined. McCrae and colleagues also found declines in divergent processing tasks with aging, however the tasks they used focused on speed of processing rather than originality (McCrae et al., 1987).

Is cortical connectivity important to associative processing?

Obviously, a loss of white matter can affect the connectivity of the brain as a whole. Connectivity enables the spread of activation from one neural network to another and thus from one activated concept to another. This spread enables a greater range of concepts being activated and therefore a broader range of response possibilities. There is some empirical support for the idea that connectivity of different networks is involved in creative associative processing. Petsche (1996) had normal subjects create a short story using 10 associated words. The results of the study showed that there was an anatomically distributed coherence of EEG oscillations during performance of this task. Connectivity between the two hemispheres may also play a crucial role in creativity as studies have shown increased right hemisphere activity when subjects are asked to make novel or unusual associations (Beeman, 1998; Bekhtereva, Starchenko, Klyucharev, Vorobev, Pakhomov, & Medvedev, 2000; Howard-Jones, Blakemeore, Samuel, Summers, & Claxton, 2005).

Right hemisphere function

The right hemisphere may play a crucial role in creativity. Creativity often requires the use of skills and knowledge mediated by both the right and left hemispheres (Heilman, Nadeau, & Beversdorf, 2003) meaning that interhemispheric communication might be as important for creativity as communication within the hemisphere. In fact, disconnection of the hemispheres such as occurs in commissurotomy, has been shown to negatively affect creative ability as measured by performance on the Rorschach test (Lewis, 1979). The right hemisphere is involved in global processing, which is important for being able to see how disparate objects or concepts are related.

The right hemisphere is also the main source of visuospatial processing. It has been hypothesized that the right hemisphere shows a greater decline in function with aging than does the left hemisphere (Albert & Moss, 1988; Brown & Jaffe, 1975). Studies investigating this hypothesis compared older adults' performance on tasks reliant on either right hemisphere dominant skills such as visuospatial ability or left hemisphere dominant skills such as language processing ability. Goldstein & Shelley (1981) found that older adults were less impaired in verbal processing skills as did Klisz (1978) and Koss and colleagues (1991). However other researchers (e.g., Libon, Glosser, Malamut, Kaplan, Goldberg, Swenson, & Prouty Sands, 1994) have suggested that task complexity may not have been well controlled in these studies, and it may be a deficit in executive functioning that underlies the visuospatial deficit. It has also been posited that only certain areas of the right hemisphere are more affected by normal aging and that is why results of studies have been inconsistent (Gerhardstein, Peterson, Rapcsak, 1998).

Memory

There are many changes that occur in cognitive processes with normal aging. Some cognitive processes appear to be untouched by aging while others show clear declines. Most deficits in aging can be traced to tasks that require the formation of new memories, whereas tasks that rely on familiar or pre-existing memories may remain intact.

There have been several conventions used to refer to different types of memory. One of the first distinctions was between long and short term memory (Atkinson & Shiffrin, 1968). These distinctions were later amended to include subtypes of both long and short term memory types (Schacter & Tulving, 1994). Long term memories can be either declarative (i.e., episodic, autobiographical, and semantic) or non-declarative (i.e., procedural). Episodic memory refers to information that was acquired in a particular place at a particular time (Tulving, 1972). Autobiographical refers to memory for the history of one's own life. Semantic memory consists of all the facts we know about the world around us (e.g., the capital of Florida is Tallahassee and that an orange is a fruit), as well as the meanings of words (Tulving, 1972). The semantic memory for words and their meanings is often referred to as the semantic system and will be discussed in more detail in a following section ("Language use"). Semantic memory has no reference to temporal or spatial context, meaning that semantic memories are not "tagged" to tell us where or when we learned the information. It is episodic memory that contains the traces of experienced events or episodes (Wheeler, Stuss & Tulving, 1997).

Studies have shown that the type of long term memory most often seen to be impaired in aging is episodic memory (Hoyer & Verhaeghen, 2006; Light & Burke, 1988). In contrast, autobiographical memory is largely intact. The evidence for the impact of aging on semantic memory is more mixed. For the most part, studies have shown that the structure of semantic memory is intact (see for example, Park et al., 2002). However, accessing or retrieving those memories can be problematic for older adults (Mackay & Burke, 1990). Procedural memory is also largely unimpaired by aging (Hoyer & Verhaeghen, 2006). It is important not to confuse memory with learning however. Acquiring new semantic or procedural memories may take longer for older adults and require more repetition when compared to younger adults learning the same information.

Working memory is a type of short term memory that entails not only retention but also manipulation or transformation of the recalled information (Keefover, 1998). Working memory is often assessed through the use of “maintenance plus processing” tasks, such as the reading span test. In the reading span test, an individual reads a sentence and then must recall the final word while also paying attention to the meaning of the sentence as comprehension is also assessed. Reading span is determined by how many sentences the individual can read and recall the final words for while also showing comprehension of the meanings. Reading span has been shown to decrease with age (Norman, Kemper, & Kynette, 1992), as have other tests of working memory ability in older adults (Dobbs & Rule, 1989). Working memory involves functions controlled by the frontal regions of the brain which are shown to be preferentially affected by aging (Bryan & Luszcz, 2000), and in fact is the executive component of working memory tasks (i.e., processing) rather than the short term maintenance component that is more affected by aging (Gick, Craik, & Morris, 1988).

Language use

For many years it was thought that verbal ability was relatively spared by normal aging, an impression fostered by studies that showed declines with aging on performance subtests of the Wechsler Adult Intelligence Scales (WAIS) (Wechsler, 1981), but no significant decline with aging on the verbal subtests. In fact, many aspects of language do remain relatively untouched by age, but some do not. Age related changes in language use are important because domain-specific knowledge is a prerequisite for creativity (Weisberg, 1999) and in the case of verbal creativity, language proficiency is the required domain-specific knowledge.

There are many aspects involved in proficient language use. First, we must be able to comprehend language in order to use it. Comprehension involves the ability to decipher the stream of language and parse it into the sounds that constitute the words of a given language. We then have to be able to retrieve the meaning of the words from semantic memory. The stored representations of words and their meanings constitute the semantic system. We also need to be able to decode the syntactic structure of the sentence or phrase the words are embedded in, in order to make sense of the spoken message as a whole. This process is similar for written language but requires the decoding of orthographic symbols used to denote sounds that make up words. Studies with older adults have found that basic language comprehension is largely untouched by normal aging (Shadden, 1997). If we take some amount of normal hearing loss into account, older adults are able to parse sounds into words as well as younger adults and grammaticality judgment tasks have shown us that older adults are just as good as younger adults at decoding syntactic structures, although there is some decline seen in the complexity of grammatical structures used by older adults (Kemper, 1987).

While basic comprehension and semantic memory have been shown in previous studies to be mostly intact, aspects of language production have been shown to be affected by normal aging. One of the most commonly reported language deficits in aging is word retrieval. This deficit has been demonstrated by slower and less accurate performance by older adults in confrontation naming tasks both of pictures and definitions (Bowles & Poon, 1985). It is also one of the most commonly reported deficits by older adults themselves. Older adults are also more likely to experience tip-of-the-tongue states (Burke, Worthley, & Martin, 1988). Older adults also have shown decreases in verbal fluency in category tasks (e.g., name all the animals you can think of…) (Kozora & Cullum, 1995; Troyer, Moscovitch, & Winocur, 1997). It has been suggested that it is access to the semantic representations and to the phonological forms of the words that causes older adults' difficulty with naming and verbal fluency rather than loss of the representations themselves (Mackay & Burke, 1990; Salthouse, 1988).

The results of studies investigating the semantic system have indicated that the representations of words and their meanings are largely intact in aging. Vocabulary tests assess the range of the semantic system, and studies have shown that vocabulary does not diminish with age, but in fact, stays stable or increases (Verhaeghen, 2003). Researchers have also examined the stability of the semantic system through semantic priming effects testing. Semantic priming tests measure the reduction in time required to identify a word when it follows a related word (i.e., if “lion” is followed by the word “tiger”, tiger will be identified more quickly as a real word than if it followed an unrelated word such as “dishwasher”). This effect is attributed to activation of networks that encode semantically related words. There has been found to be no significant difference in performance on this type of task between young and older adults (Howard & Burke, 1984). Mediated semantic priming has also been investigated wherein the first and second words are related through a third unstated word (e.g., “stripes” followed by “lion” results in faster identification of lion through the related but unstated word “tiger”). This type of priming is also largely unaffected by aging (Bennett & McEvoy, 1999).

Another method that can be used to investigate the semantic system is word association tasks. The associative connections that one word has to other words form a part of the structure of a representation for that word. It may be that semantic representations as a whole are largely available in normal aging, but that the structure of the representations has changed or. Connections between words could be lost or altered, therefore affecting the organization of the semantic system as a whole (Kausler, 1994). Confrontation naming tasks would not necessarily show if a change in the organization of the semantic system occurred with aging, whereas association tasks might. There have been some studies investigating this possibility which have looked at three main variables of the associates produced: overall number of responses, frequency or commonness of the response, and variability in response over different administration episodes. Researchers have also compared the classes of associations provided. A paradigmatic association is from the same grammatical class as the cue word, for example, a paradigmatic associate for “mountain” would be “hill”. A syntagmatic associate is from a different grammatical class and could co-occur in a sentence with the cue word. An example of this kind of associate would be the word “climb” for the cue word “mountain” (Kausler, 1994).

Some early studies reported differences between young and older adults performance (Perlmutter, 1979; Riegel & Birren, 1966) on all of the above variables, but later studies did not find strong age differences and suggested that earlier findings were linked more to vocabulary level than to true differences with increasing age (Burke & Peters, 1986, Lovelace & Cooley, 1982). Additionally, Lovelace and Cooley (1982) found that high vocabulary scores in both young and older adults were associated with producing more common (i.e., more frequent) responses on word association tasks. This finding is in line with Howard (1980) who examined variability of responses when older adults generated properties of a stimulus word. Older adults produced fewer unique responses, that is, responses that were generated by only one participant. Hirsh and Tree (2001) in a study attempting to provide word association norms reported a similar finding; younger adults produced a wider variety of responses, more unique responses, and more instances of providing non-dominant responses.

While the findings of Burke and Peters (1986) as well as Lovelace and Cooley (1982) were taken by the authors to indicate that the organization of the semantic system remains unchanged by aging, the findings that older adults produce less unique or creative responses may indicate that their associative horizons are narrowed, such that fewer associates for a given word are available. None of the above studies asked the participants to provide more than 4-5 associates for any word. It is unknown whether any differences between young and older adults would emerge in this kind of association task.

Another aspect of language use that is relevant to the current study is the production of discourse. Discourse is considered to be any unit of language larger than a single word (Myers, 1999), and as such there are many types of discourse. Discussing the effects of age on all types of discourse would be beyond the realm of this study and so we will focus here on the studies that investigated narrative discourse.

Narrative discourse involves the telling of some kind of story. Most studies to this point have used picture description tasks, either of single pictures or a series of pictures showing an event unfolding (i.e., a “cartoon”), or have used story re-telling or the telling of stories from the participant’s own life (i.e., autobiographical stories). There are several aspects of narrative that can be investigated. These include number of words used, content informativeness, cohesion of the story, and overall quality. There have been a number of studies investigating whether these aspects of narrative discourse are different in young and older adults and the results have not always agreed.

Most studies looking at number of words have found that younger and older adults produce similar amounts of words in non-personal story telling (i.e., picture or cartoon description) (Beaudreau, Storandt, Strube, 2006; Cooper, 1990; James et al., 1998). However, differences in number of words used have been found to be significantly greater in older adults when telling personal stories (i.e., stories from the adults’ own lives). Education level, more than age, has been shown to be related to number of words produced in a discourse, with lower education levels resulting in lower word counts (Mackenzie, 2000).

In contrast, age differences have been found in studies investigating the content of discourse. Content is a measure of informative of the discourse, that is, how much appropriate and relevant information is conveyed by what is said. In one study, older adults were found to produce significantly more irrelevant content when answering questions about their own lives (Glosser & Deser, 1992). Other studies have found similar results, that older adults are more likely to produce a larger proportion of irrelevant utterances than do younger adults in spontaneous speech and when talking about their own lives (Arbuckle & Gold, 1993; James et al., 1998; Pushkar, Basevitz, Arbuckle, Nohara-LeCalir, Lapidus, & Peled, 2000). However, older adults do not produce any more irrelevant information than do younger adults in non-personal discourse such as story description (James et al., 1998).

Studies investigating cohesion of narratives have also found differences. Cohesion is a measure of how well utterances in a given discourse are linked. Cohesion is maintained through appropriate use of pronouns, conjunctions, and determiners to substitute for or refer back to another noun. It has been shown that older adults make more errors of reference in story re-telling tasks (Pratt, Boyes, Robins, & Manchester, 1989) and in telling and understanding stories (Kemper, Rash, Kinnette & Norman, 1990). Older adults also have more difficulty with appropriate use of conjunctive cohesions (Juncos-Rabadan, 1996). Mackenzie (2000) found that older adults had more difficulty with appropriate topic maintenance in spontaneous speech, but this effect was not found when older adults were asked to describe pictures.

Quality of discourse has also been investigated, but as this is a largely subjective measure, the findings in this area are not as clear-cut. James and colleagues (1998) reported that older adults produced more irrelevant utterances in recorded discourse about personal topics; however, these same samples of discourse were rated as being more interesting than younger adults recorded personal discourses. Pratt & Robins (1991) report a similar finding, in that older adults were rated as producing a higher quality of narrative discourse. There is very little literature currently on age differences in newly created stories. It is possible that the same age differences would be seen as have been reported for story telling based on cartoon picture stimuli (e.g., Juncos-Rabadan, 2005), however, that remains to be shown.

Purpose of the Study

With aging there are changes of the brain and brain functions. Whereas some functions have been reported to improve with aging (e.g., vocabulary) others have been reported to diminish (e.g., working memory). In addition, there is a loss of white matter connections and a decrease in some functions mediated by the frontal lobes. Connectivity, both interhemispheric and intrahemispheric, and frontal lobe functions have been shown to be linked to creative processing. The objective of this study was to investigate the relationship between normal aging and different elements of creative verbal processing, including attempting to learn whether aging affects some types of processing more strongly than others. This study will include tasks to assess each of the elements mentioned above, to learn how each contributes to verbal creative ability in older adults.

Hypotheses and Predictions

Hypothesis-Prediction 1: Divergent Verbal Processing

Previous studies have shown that older adults have a larger vocabulary than younger adults when education level is controlled. Because of this previous finding and the fact that learning new words does not require disengagement or activation of large distributed networks, older adults (OAs) in our sample should perform as well or better on a test of vocabulary. However, unlike vocabulary, divergent processing is heavily dependent on frontal-executive functions such as disengagement, and OAs have been shown to be less proficient in many tasks that are dependent on frontal-executive functions. Thus, if vocabulary level is controlled, we predicted that OAs performance on a task requiring divergent verbal processing would be worse than YAs.

Hypothesis-Prediction 2: Convergent Verbal Processing

Convergent verbal processing, finding similarity or commonality in words or concepts, is dependent on knowledge of semantic relationships. This knowledge is often learned and thus might improve with healthy aging. However, when relationships have not been learned, but need to be formulated, we predicted that OAs performance would be poorer than YAs.

Hypothesis-Prediction 3: Divergent and Convergent Associative Verbal Processing

As discussed above, Divergent processing, or finding alternative solutions, is in part dependent upon activating a large array of semantic-conceptual networks that have some form of association. Convergent processing also requires the activation of lexical-semantic representations as well as the conceptual network that allows a person to discern the relationship between these lexical-semantic representations. Since normal aging affects cortical connectivity and connectivity is required for activation of a wide variety of semantic networks, we predicted that OAs would perform more poorly on associative tasks than YAs.

Hypothesis-Prediction 4: Creative Verbal Production

OAs have been shown in previous studies (e.g., James et al., 1998; Pratt & Robins,1991) to produce narratives that were rated as being more interesting than those produced by YAs. Results such as these could suggest that OAs would produce stories that are more creative than YAs. However, the storytelling task used in this study is constrained in that it requires the participant to use three semantically unrelated words in the produced story. This will require associative processing of novel relationships as well as divergent and convergent processing. Associative processing is dependent on cortical connectivity which is affected by aging, and divergent processing is dependent on frontal function which has also been shown to be affected by aging. Therefore, for the storytelling task used in this study, we predicted that OAs would have lower scores on a task of constrained story telling than YAs.

Hypothesis-Prediction 5: Associations between Type of Verbal Processing, Creative Verbal Production and Standard Measures of Language and Cognitive Ability

Many of the tests used to investigate creative processing in this study have not been investigated in terms of their relationship to aging or in relation to standard cognitive measures. For this reason we were interested in how the measures would correlate with each other as well as with standard cognitive measures. We predicted that the convergent measures would correlate with measures of lexical-semantic knowledge and that divergent tasks would correlate with measures of frontal function or working memory. Furthermore, we predicted that measures of uniqueness in divergent tasks would correlate with production of more highly creative stories in the constrained story production task.

CHAPTER 3
METHODS

Participants

The participants for this study were 30 healthy younger adults (12 males, 18 females) and 30 healthy older adults (8 males, 22 females). They ranged in age from 18-30 years for younger adults and 65-80 years for older adults. Healthy younger adult participants were recruited from undergraduate classes at the University of Florida as well as from the community at large. Healthy older adult participants were recruited via presentations at community social events and local retirement communities as well as responses from flyer postings.

The sample size was based on results of a prospective power analysis assuming a level of significance of 0.05, and a sample size of 30 in each group, which showed that we would be able to detect an effect size of .74 with power above .80. Cohen (1992) regards 0.2 as indicative of a small effect, 0.5 a moderate and 0.8 a large effect size. Therefore, with a total sample of 60 participants, we would be able to detect a moderate to large effect in the data.

All participants were right handed, (assessed using the Benton Handedness Questionnaire), native speakers of English with at least 12 years of education, who were willing to participate and provided informed consent. Individuals with a history of traumatic brain injury, stroke or any neurological diseases were not included in this study due to differences in cognitive and language functioning that can result. Individuals with a reported history of developmental disorders such as language learning disorders (e.g., dyslexia) or attentional deficit disorder were not included in the study. Persons with chronic medical illnesses that can result in vital organ failure were also not included (e.g., hepatic, renal, congestive heart failure, as well as chronic obstructive pulmonary disease). Depressive symptoms were screened for using the Beck Depression Inventory (BDI) (Beck, 1987), as depression can also affect cognitive functioning. The BDI is a 21-item scale with scores ranging from 0 (absent) to 3 (severe) for all items. Score is the sum of all items, with a score above 11 being a guideline for presence of depression (Gallagher, Breckenridge, Steinmetz, & Thompson, 1983). None of our older or younger participants scored above 11. Healthy older adult participants were given the Mini-Mental Status Exam (MMSE) (Cockrell & Folstein, 1988) to screen for cognitive impairments. One possible participant was excluded from the study after scoring below the range of normal (≥26). All other older adults were in the range of normal. Healthy younger participants were not given the MMSE as it was not considered necessary to rule out age-related cognitive impairment in that group. Means and standard deviations for demographic data as well as scores on exclusionary tests can be found in Table 3-1.

Tests of Language and Cognitive Ability

Creativity is dependent upon a number of cognitive functions including domain specific knowledge (e.g., lexical-semantic knowledge), working memory, and executive functions. These functions were assessed before beginning the experimental tasks. Elements of the cognitive testing were administered in the order in which they are described below.

Lexical-semantic knowledge was assessed using two vocabulary tests. One was the WAIS-R vocabulary test which can be used as an indicator of verbal IQ. The other, a word retrieval task was a measure of descriptive auditory naming based on normative data found in the work of Hammeke and colleagues (2005). We included this measure of word retrieval because we were interested in the participant's ability to retrieve a semantic representation from a verbal description rather than a picture because we wanted to assess participant's ability to retrieve words in the same modality (i.e., verbal) that we were investigating. The measure consisted of 40 words, both living and nonliving and was presented in auditory form. The participant heard a description of a common animal or object (e.g., "an animal that makes honey") and was given time to speak the answer "bee".

Working memory was assessed using an operation span (OSPAN) task (Turner & Engle, 1989). OSPAN is a dual-task paradigm which involves math and memory processing. Participants were asked to read and verify a simple math problem (e.g., 14 / 7 = 2, true or 15 / 5 = 2, false) then were shown a word (e.g., bottle). The participants were asked to remember the words they were shown following the math problem. The number of words an individual was able to remember after being shown a series of problems and words was the OSPAN score.

Creative processing requires divergent processing, and divergent processing is thought to rely on two components, disengagement and the formulation of alternate responses or solutions. Disengagement requires the ability to switch sets, to shift from one response set to an alternate response set. We assessed disengagement in a verbally based task, the STROOP Neuropsychological Screening Test (SNST) (Trenerry, Crosson, DeBoe, & Leber, 1989). This test has two tasks. The first required the participant to read a list of words consisting of the names of colors written in a different color than the name (e.g., the word "blue" written in red ink). The participant was asked to read the words aloud. In the second task the participant was given a similar list of words (i.e., color names written in different colors than the name) and asked to say aloud the color the word was printed in (i.e., in example above, participant needed to respond with the word “red” which described the ink color, rather than the word “blue”). This required the participant to disengage from the prepotent response which is to read the word, and instead provide an aspect of the appearance of the word. The difference in time to complete the first task and to complete the second task (measured in seconds) was used as the score for this test.

Participants were also asked to fill out a short self-report questionnaire about creativity. The Scale of Creative Attributes and Behavior (SCAB) (Kelly, 2004) is a 20-item inventory that asks participants to rate their propensity to be involved in creative thinking or activities. Examples of items include, “I enjoy creating new things”, and “I have an ability to find the hidden potential of ideas that others often can’t see”. Each of the 20 items on the questionnaire is rated on a 7-point scale ranging from “strongly agree” to “strongly disagree”.

Testing Procedures

All participants were assessed in a quiet room either at the University of Florida or in their homes. All participants were consented using an IRB approved Informed Consent Form prior to initiation of any testing. Testing started with the depression scale and MMSE for older adults. If scores on these tests were not exclusionary, testing proceeded to the cognitive measures. The order of administration of the Unusual Uses, Associative Fluency, WAIS-R Similarities, RAT, and the Storytelling task were randomized for each participant.

Experimental Tests of Verbal Creative Processing

Hypothesis-Prediction1: Divergent Verbal Processing

Divergent verbal processing has been reported to be associated with frontal activation (Heilman et al., 2003). The measure used to asses verbal divergent processing in this study was the Unusual Uses test (Guilford, 1978), which has been found to be sensitive to frontal lobe dysfunction in individuals with frontal tumors (Butler et al., 1993). This task was intended to assess flexibility of thought and divergent processing. The participants were asked to list as many alternate or unusual uses as they could imagine for five common objects: brick, pencil, paperclip, toothpick, and sheet of paper. Since it is known that frontal lobe deficits are common in normal aging, we assessed whether divergent processing as evidenced by performance on the Unusual Uses Test was affected by age. The Unusual Uses test had two outcomes:

- Fluency - outcome/response variable is numerical (1-30+)
- Uniqueness - outcome/response variable is numerical (.0001 – 1)

Uniqueness was calculated by determining a given responses' frequency of occurrence within the entire corpus of responses from all 60 participants. A response with a relatively high number of occurrences in the list of all responses therefore had a lower value (e.g., .032), whereas a more unique response had a higher value (e.g., .75). A response that occurred only once had a value of 1.

A multivariate analysis of variance (MANOVA) with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables was used to compare performance on the Unusual Uses Test. A multivariate analysis of covariance (MANCOVA) with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables with the cognitive factor and verbal factor as covariates was used to compare performance controlling for the level of cognitive and verbal skill.

Hypothesis-Prediction 2: Convergent Verbal Processing

Convergent processing requires the ability to find the one correct answer or the best possible answer. Convergent verbal processing, finding similarity or commonality in words or concepts, is dependent on knowledge of semantic relationships. If education level is controlled, older adults have been shown to have larger vocabularies on average than younger adults, indicating a greater number of semantic representations which could enhance performance on a verbally based convergent task. However, older adults have also been shown to have deficits in accessing semantic representations which, together with reported decreases in cortical connectivity, may adversely affect performance on a convergent verbal processing task.

The task used to investigate this question in our study was the WAIS-R similarities subtest. In this test participants were asked to explain what two items had in common. The items range in difficulty from simple (e.g., orange-banana) to most difficult (praise-punishment). The outcome for the WAIS-R Similarities subtest is numerical (0-28).

A univariate analysis of variance (ANOVA) with age group (young vs. old) as a between-subjects variable and total number correct responses on task as the dependent variable was used to compare performance on the Similarities subtest. A univariate analysis of covariance (ANCOVA), again with age group (young vs. old) as a between-subjects variable and total number correct responses on task as the dependent variable with cognitive factor and verbal factor as covariates was used to compare performance controlling for the level of cognitive and verbal skill.

Hypothesis-Prediction 3: Divergent and Convergent Associative Verbal Processing

It has been reported that the structure of the semantic system is largely unchanged by age, however, to this point, the studies that assessed this using word association tasks limited the number of associates participants were asked to produce. Since we know that interhemispheric as well as intrahemispheric connectivity is affected by aging, it was possible that this change in connectivity would result in older adults producing fewer associates for a given word than younger adults, as well as producing more common (i.e., more frequent) associates. Since normal aging affects cortical connectivity and connectivity is required for activation of a wide variety of semantic networks, we predicted that OAs would perform more poorly on associative tasks than YAs. Verbal associative processing was assessed using two associative tasks.

Associative fluency

Each participant was given five words and asked to list all the words he or she could think of that were associated with the target word. There was no time limit on completion of this task. This task was audio recorded and later transcribed. Associative Fluency has two outcomes:

- Fluency - outcome/response variable is numerical (1-30+)
- Uniqueness - outcome/response variable is numerical (.0001 - 1)

Uniqueness was calculated in the same manner for this task as in the Unusual Uses Test (see description under Hypothesis/Prediction 1 above). A MANOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables was used to compare performance on the Associative Fluency task. A MANCOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables with the cognitive factor and verbal factor as covariates was used to compare performance controlling for the level of cognitive and verbal skill.

Remote associates test (RAT)

This test required respondents to access the semantic representations for three clue words and find one fourth word that was linked with all three. The clue words were able to be related to the solution word in a number of ways, (e.g., semantically or associatively related, two parts of a compound word, or words used as synonyms). For example – the trio (falling, actor, dust) with the solution “star”. “Falling” and “star” are associatively linked, “actor” and “star” are synonyms, and “stardust” is a compound word. There were 20 items in this task, response was scored for accuracy. The RATs outcome/response variable is numerical (1-20).

An ANOVA with age group (young vs. old) as a between-subjects variable and total number of correct responses on task as the dependent variable was used to compare performance on the RAT. An ANCOVA, again with age group (young vs. old) as a between-subjects variable and total number correct responses on task as the dependent variable with cognitive factor and verbal factor as covariates was used to compare performance controlling for the level of cognitive and verbal skill.

Hypothesis-Prediction 4: Creative Verbal Production

The final experimental task required a synthesis of creative processing in that it required participants to use more than one type of processing to create a novel verbal production. The participants were asked to produce four novel stories incorporating lists of words that were given to the participant in writing. The participants were given four separate lists of unrelated words (e.g., chair, star, and tulip) one list at a time, and asked to produce a short story incorporating the words. This task was based on previously reported studies (Bekhtereva et al., 2000; Howard-Jones, et al., 2005) that used fMRI to investigate areas of the brain associated with novel story generation.

The participants were instructed to be as creative as possible and to make sure that their story made sense. They were given up to two minutes before telling each story to think of a plot and then were asked to verbally relate the story to the investigator. The participants were told that the story did not need to be long and that a length of five to ten sentences would be appropriate. All participants produced a total of four stories. The ratings for the first story were used to calibrate reliability for the panel of story raters, the other three were analyzed for the experiment. The stories were judged on a 1-5 Likert scale on 5 categories: novelty/uniqueness, cohesiveness, organization, and appropriateness and an overall score.

The stories were recorded and transcribed. They were then rated by an independent panel of judges familiar with narrative discourse. The panel included a speech-language pathologist with five years experience analyzing discourse samples, a professional editor, and a creative writer. Before rating any of the stories, the judges reviewed the categories and were given definitions (shown in Appendix A) as well as a suggested guide to scoring for each category (shown in Appendix B). The stories were randomized both for group and order. The judges were then given the first stories to rate as a training measure to calibrate reliability. Resulting reliability on the first stories for all participants based on a point-by-point comparison was 84.20%.

Since associative processing is involved in both divergent and convergent processing (when relationships have not been previously learned) this may be a critical element of novel verbal productions. Since associative processing is dependent on cortical connectivity which is affected by aging, we predicted that OAs would have lower scores on the task of novel verbal production (e.g., story telling) than YAs.

A MANOVA with age group (young vs. old) as a between-subjects variable and the five rating factors used to judge the stories (novelty/uniqueness, cohesiveness, organization, appropriateness and overall score) as the dependent variables was used to compare performance on the storytelling task. A MANCOVA with age group (young vs. old) as a between-subjects variable and the five rating factors used to judge the stories (i.e., novelty/uniqueness, cohesiveness, organization, appropriateness and overall score) as the dependent variables with cognitive factor and verbal factor as covariates was used to compare performance controlling for the level of cognitive and verbal skill.

Hypothesis-Prediction 5: Associations between Type of Verbal Processing, Creative Verbal Production and Standard Measures of Language and Cognitive Ability

Many of the tests used to investigate creative processing in this study have not been investigated in terms of their relationship to aging or in relation to standard cognitive measures. For this reason, we were interested in how the measures would correlate with each other as well as with standard language and cognitive measures. We predicted that the convergent measures would correlate with measures of lexical-semantic knowledge (i.e., WAIS-R vocabulary and auditory naming) and that divergent tasks would correlate with measures of frontal function (i.e., SNST). Furthermore, we predicted that measures of uniqueness in divergent tasks would correlate with production of more highly creative stories in the constrained story production task.

Pearson correlation coefficients were used to indicate the association between story scores, creativity tests (i.e., divergent, convergent and associative tasks), and language and cognitive tests. The alpha for statistical significance was set at $p < .05$.

We conducted four separate correlations:

- Story scores and language and cognitive measures
- Creativity tests and language and cognitive measures
- Story scores and creativity tests
- Creativity tests intercorrelations

Table 3-1. Group means and standard deviations (SD) for demographic data and scores on exclusionary tests

Measure	Older Adults		Younger Adults	
	Mean	SD	Mean	SD
Age	72.93	4.99	20.21	1.88
Education	17.23	3.56	14.27	1.17
MMSE	29.17	1.32	NA	NA
BDI	3.50	3.17	4.37	3.37

CHAPTER 4
RESULTS

Group Comparisons on Tests of Language and Cognitive Ability

Older and younger adult participants' scores on a series of language and cognitive measures were compared using a series of ANOVAs. Means and standard deviations can be found in Table 4-1. OAs performed significantly better than YAs on both lexical-semantic tests; WAIS-R vocabulary [$F(1,59) = 5.48$, $p = .02$] and auditory naming [$F(1,59) = 16.90$, $p = <.001$]. OAs were significantly worse than YAs on a test of inhibition/disengagement, the STROOP color-word interference test (SNST) [$F(1,59) = 33.76$, $p = <.001$], but no significant difference was found between groups on the working memory task, operation span (OSPAN), [$F(1,59) = 1.42$, $p = .24$].

As discussed in the literature review, the processes investigated in this study (i.e., divergent verbal processing, convergent verbal processing and associative verbal processing) are thought to be in some part dependent on cognitive abilities as well as semantic abilities. We therefore planned to run covariance analyses as well as mean comparisons on all of our questions involving creative verbal processing. However, with each additional covariate added to an analysis, the likelihood of collinearity of the variables increases, which can result in adding little to the percent of variance explained and also makes interpretation of the standard errors of the individual covariates difficult. Consequently, we submitted the scores on the lexical-semantic tests as well as the cognitive tests to a principal components analysis with Varimax rotation. This factor analysis yielded two significant factors that together accounted for 68.94% of the variance in scores (see Table 4-2). Performance on the WAIS R vocabulary test and the auditory naming tests showed the highest loadings on Factor 1, we named this the verbal factor. Similarly, performance on the SNST and the OSPAN had the highest loadings on Factor 2; therefore, we have named this the cognitive factor. Because a higher score on Factor 2 was indicative of lower performance level while high scores on the verbal factor indicated better performance, we transformed the cognitive factor scores by multiplying them by negative one for ease of interpretation. Thus, higher verbal and cognitive factor scores indicate better performance in both domains. These two factors will be used in all analyses of covariance described below.

Group Comparisons on Experimental Tests of Creative Verbal Processing

Analyses for Hypothesis-Prediction 1: Differences between Younger and Older Adults in a Divergent Verbal Processing Task (Unusual Uses Test)

A MANOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables was used to compare performance on the Unusual Uses Test. Means and standard deviations for all MANOVAs (and ANOVAs) are shown in Table 4-3. The multivariate tests showed no significant multivariate effect for group [$F(1,58) = 2.90$, $p = .06$, partial $\eta 2 = .092$]. However, the tests of between-subjects effects which looked at the dependent variables individually, showed a significant group effect for uniqueness [$F(1,58) = 5.026$, $p = .02$, partial $\eta 2 = .080$], but not for total fluency [$F(1,58) = .03$, $p = .862$, partial $\eta 2 = .001$].

A MANCOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables with the cognitive factor and verbal factor as covariates was also computed. The multivariate tests showed no significant multivariate effect of the verbal factor on overall performance [$F(1,53) = .30$, $p = .74$, partial $\eta 2 = .011$], and no significant effect of the verbal factor on the dependent variables individually, mean uniqueness [$F(1,53) = .09$, $p = .77$, partial $\eta 2 = .002$] or total fluency [$F(1,53) = .38$, $p = .54$, partial η2 = .007]. The multivariate tests did show a significant multivariate effect of the cognitive factor on overall performance [$F(1,53) = 3.95$, $p = .03$, partial η2 = .130] with a significant effect on total fluency [$F(1,53) = 7.71$, $p = .008$, partial η2 = .125] but not on mean uniqueness [$F(1,53) = 1.77$, $p = .19$, partial η2 = .032].

In sum, a significant difference between younger and older adults was found for mean uniqueness, showing that older adults produced significantly more unique responses than younger adults. However, when the effect of performance on cognitive tests was used as a covariate, the cognitive factor was found to have a significant multivariate group effect as well as a significant effect on total fluency, but did not have a significant effect on mean uniqueness.

Analyses for Hypothesis-Prediction 2: Differences between Younger and Older Adults in a Convergent Verbal Processing Task (Similarities Subtest)

An ANOVA with age group (young vs. old) as a between-subjects variable and total number of correct responses on the task as the dependent variable was used to compare performance on the Similarities subtest. Means and standard deviations are shown in Table 4-3. The tests of between-subjects effects showed a significant group effect [$F(1,54) = 9.06$, $p = .004$, partial η2 = .139], with older adults producing significantly more correct responses. An ANCOVA, again with age group (young vs. old) as a between-subjects variable and total number of correct responses on task as the dependent variable and the cognitive factor and verbal factor as covariates was also computed. Group significance was maintained when controlling for the covariates of verbal ability and cognitive skills [$F(1,54) = 11.69$ $p < .001$, partial η2 = .403]. The verbal factor was found to have a highly significant effect on performance on the WAIS-R

Similarities subtest with [$F(1,54) = 19.55$, $p < .001$, partial $\eta 2 = .273$]. However, the cognitive factor was not significant [$F(1,54) = .20$, $p = .66$, partial $\eta 2 = .004$], indicating little to no predictive effect on performance on this task.

In sum, OAs performed significantly better on this convergent processing task than did the YAs. Performance on the lexical semantic tests (i.e., the verbal factor) was significantly associated with performance on the Similarities subtest. Nevertheless, group performance remained significantly different when verbal ability was covaried.

Analyses for Hypothesis-Prediction 3: Differences between Younger and Older Adults in Associative Verbal Processing Tasks

Associative Fluency: A MANOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables was used to compare performance on the Associative Fluency task. Means and standard deviations are shown in Table 4-3. The multivariate tests showed a highly significant main effect for group [$F(1,58) = 8.90$, $p < .001$, partial $\eta 2 = .238$]. The tests of between-subjects effects which looked at the dependent variables individually, also showed a significant group effect for mean uniqueness [$F(1,58) = 6.03$, $p = .017$, partial $\eta 2 = .094$], but not for total fluency [$F(1,58) = .1.79$, $p = .186$, partial $\eta 2 = .030$]. OAs produced a greater proportion of unique items than YAs, although the total number of items produced did not differ by group.

A MANCOVA with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables using the cognitive factor and verbal factor as covariates was also computed. Group significance was maintained while controlling for the covariates of verbal ability and cognitive skills [$F(1,58) = 9.54$, $p < .001$, partial $\eta 2 = .265$]. The multivariate tests showed no significant multivariate effect of the verbal factor on overall performance [$F(1,58) = 2.05$, $p = .14$, partial $\eta 2 = .072$] and no significant effect of the verbal factor on the dependent variables individually, mean uniqueness [$F(1,58) = 2.45$, $p = .12$, partial $\eta 2 = .123$] or total fluency [$F(1,58) = .02$, $p = .88$, partial $\eta 2 = .000$]. The multivariate tests also did not show a significant multivariate effect of the cognitive factor on overall performance [$F(1,58) = 2.45$, $p = .10$, partial $\eta 2 = .085$]. However, the cognitive factor did show a significant effect on mean uniqueness [$F(1,58) = 4.78$, $p = .03$, partial $\eta 2 = .081$] but not on total fluency [$F(1,58) = 2.72$, $p = .11$, partial $\eta 2 = .048$].

In sum, a highly significant group difference between OAs and YAs was found on performance in the Associative Fluency task, which was maintained even when verbal and cognitive skill level were covaried. OAs produced significantly more unique responses than did the YAs. Verbal skill level was not found to predict this, but cognitive ability did predict performance on the dependent variable of mean uniqueness. This finding is in opposition to the finding in Hypothesis 1, in which the cognitive factor was found to have a significant group effect as well as a significant effect on total fluency but not on mean uniqueness.

The RAT: An ANOVA with age group (young vs. old) as a between-subjects variable and total number of correct responses on task as the dependent variable was used to compare performance on the RAT. Means and standard deviations are shown in Table 4-3. Although OAs had showed a larger mean number of correct responses, the tests of between-subjects effects showed no significant group effect [$F(1,58) = 2.23$, $p = .140$, partial $\eta 2 = .037$].

An ANCOVA, again with age group (young vs. old) as a between-subjects variable and total number of correct responses on task as the dependent variable with cognitive factor and verbal factor as covariates was also computed. The multivariate effect of Group was significant [$F(1,56) = 2.88$, $p = .04$, partial $\eta 2 = .138$] when the effects verbal and cognitive ability were controlled. The verbal factor was found to have a highly significant effect on performance on the RAT [$F(1,5) = 6.73$, $p = .01$, partial $\eta 2 = .111$]. However, the cognitive factor was not significant [$F(1,56) = .16$, $p = .70$, partial $\eta 2 = .003$], indicating little to no predictive effect on performance on this task.

In sum, OAs performed significantly better on this convergent associative processing task than did the YAs, when verbal ability was covaried. Verbal ability was significantly associated with performance on this task. This finding is similar to the finding in Hypothesis 2, wherein OAs produced significantly more correct responses on a convergent processing task, the WAIS-R Similarities test.

Analyses for Hypothesis-Prediction 4: Differences between Younger and Older Adults in a Creative Verbal Production Task (Storytelling)

A MANOVA with age group (young vs. old) as a between-subjects variable and mean score across all three stories for the 5 rating factors (novelty/uniqueness, cohesiveness, organization, appropriateness and overall score) as the dependent variables was used to compare performance on the storytelling task. The multivariate tests showed a highly significant multivariate effect of Group [$F(1,54) = 5.22$, $p < .001$, partial $\eta 2 = .343$] in favor of YAs. The tests of between-subjects effects which looked at the dependent variables individually, also showed a significant group effects for mean appropriateness [$F(1,54) = 8.96$, $p = .004$, partial $\eta 2 = .142$], mean uniqueness [$F(1,54) = 18.33$, $p < .001$, partial $\eta 2 = .253$], and mean overall score [$F(1,54) = 22.21$, $p < .001$, partial $\eta2$ = .291]. YAs received significantly higher (better) scores in all three categories. Group differences only showed a trend toward significance for mean cohesion [$F(1,54) = 3.11$, $p = .08$, partial $\eta2$ = .055] and mean organization [$F(1,54) = 2.68$, $p = .11$, partial $\eta2$ = .047].

A MANCOVA with age group (young vs. old) as a between-subjects variable and mean score for the 5 rating factors as the dependent variables with the cognitive factor and verbal factor as covariates was also computed. The multivariate effect of group remained highly significant [$F(1,54) = 5.54$, $p < .001$, partial $\eta2$ = .376], and there was also a significant effect of the verbal factor [$F(1,54) = 2.73$, $p = .03$, partial $\eta2$ = .229], but not the cognitive factor [$F(1,54) = .41$, $p = .84$, partial $\eta2$ = .043]. The tests of between-subjects effects showed that when verbal and cognitive ability were controlled, all five rating factors became significantly different between groups with YAs outperforming OAs in all five categories: mean cohesion [$F(1,54) = 3.19$, $p = .03$, partial $\eta2$ = .161], mean organization [$F(1,54) = 4.77$, $p = .005$, partial $\eta2$ = .222], mean appropriateness [$F(1,54) = 4.67$, $p = .006$, partial $\eta2$ = .219], mean uniqueness [$F(1,54) = 6.20$, $p = .001$, partial $\eta2$ = .271] and mean overall score [$F(1,54) = 10.12$, $p < .001$, partial $\eta2$ = .378]. The verbal factor was significantly associated with performance in three of the five categories: mean cohesion [$F(1,54) = 6.0$, $p = .02$, partial $\eta2$ = .107], mean organization [$F(1,54) = 7.52$, $p = .008$, partial $\eta2$ = .131], and mean overall score [$F(1,54) = 5.80$, $p = .02$, partial $\eta2$ = .104]. The verbal factor was not significantly related to performance on the uniqueness category [$F(1,54) = 1.40$, $p = .24$, partial $\eta2$ = .027] or mean appropriateness [$F(1,54) = 3.60$, $p = .06$, partial $\eta2$ = .067], however. Controlling for the cognitive factor did not significantly associate with performance in any of the five categories used to judge the stories.

In sum, OA participants' stories were scored more poorly particularly in uniqueness, appropriateness and overall score. Without controlling for verbal ability or cognitive skill level, those three categories were significantly different between groups, but cohesion and organization were not. However, when verbal ability was controlled, OA participants were judged as having performed more poorly on all rating categories although the verbal factor did not predict performance on uniqueness or appropriateness scores. The cognitive factor did not predict performance.

Analyses for Hypothesis-Prediction 5: Associations between Type of Verbal Processing, Creative Verbal Production and Standard Measures of Language and Cognitive Ability

Pearson correlation coefficients were used to indicate the association between story scores, creativity tests (divergent, convergent and associative tasks), and language and cognitive tests. The alpha for statistical significance was set at $p < .05$. We conducted four separate correlations discussed below in turn.

Story scores and language and cognitive measures: Pearson Product Moment Correlations among the five story scores and the lexical-semantic and cognitive measures are presented in Table 4-4 and 4-5. Several tables were divided into two parts due to the large number of correlations being performed. The strongest correlation was found between the score on the test of disengagement (SNST) and the uniqueness score [$r(56) = -.469$, $p < .001$], and the overall score [$r(56) = -.499$, $p < .001$]. This indicates that a higher score on the SNST (i.e., greater difficulty with disengagement from a prepotent response) was significantly and negatively related to higher uniqueness and overall scores. Performance on the WAIS-R vocabulary was significantly correlated with the organization score [r(56) = .281, *p*= .036].

There were a number of positive correlations among the story scores themselves as well. These included correlations between cohesion and organization [r(56) = .598, *p*< .001], between organization and appropriateness [r(56) = .318, *p*= .017], and organization and overall score [r(56) = .340, *p*= .010], appropriateness and overall score [r(56) = .439, *p*= .001], and between originality and appropriateness [r(56) = .299, *p*= .025] and originality and overall score [r(56) = .917, *p*< .001].

Creativity tests and language and cognitive measures: Correlations between the divergent, convergent and associative creativity tests and the lexical-semantic and cognitive measures are presented in Tables 4-6 and 4-7.

Performance on the RAT was significantly associated with performance on the WAIS-R vocabulary test [r(60) = .296, *p*= .021] as well as auditory naming [r(60) = .371, *p*< .004]. Performance on the WAIS-R similarities was also significantly associated with performance on the WAIS-R vocabulary test [r(58) = .555, *p*< .001] as well as auditory naming [r(58) = .476, *p*< .001]. Total fluency on the Associative Fluency task was significantly and negatively correlated with performance on the SNST [r(58) = -.276, *p*= .036], and total fluency on the Unusual Uses task was significantly correlated with performance on the OSPAN [r(60) = .332, *p*= .010].

Story scores and creativity tests: Correlations between the five story scores and the divergent, convergent and associative creativity tests are presented in Tables 4-8 and 4-9. The story score for cohesion was significantly and negatively related to total fluency on the Associative Fluency task [r(56) = -.328, *p*= .014] as well as mean uniqueness [r(58) = -.276, *p*= .039], and mean uniqueness on the Unusual uses test as well [r(58) = -.300, *p*= .024]. The story score for organization was significantly and negatively related to mean uniqueness on the Unusual uses test as well [r(58) = -.309, *p*= .021].

Creativity test intercorrelations: Correlations between the divergent, convergent and associative creativity tests are presented in Table 4-10. There were a number of positive correlations among the creativity tests. The RAT and the WAIS-R similarities subtest were significantly related [r(58) = .323, *p*= .013]. In addition, the WAIS-R similarities subtest was significantly related to total fluency on the Unusual Uses test [r(58) = .273, *p*= .038]. The Unusual Uses test and the Associative Fluency task were significantly intercorrelated on both mean uniqueness scores for both tests as well as mean uniqueness scores for both tests (mean uniqueness scores for both tests [r(58) = .426, *p*=.001], total fluency scores for both tests [r(60) = .556, *p* < .001], both parts of Associative Fluency (mean uniqueness and total fluency) [r(60) = .503, *p* < .001], both parts of Unusual Uses (mean uniqueness and total fluency) [r(60) = .299, *p*=.020], Associative Fluency total fluency and Unusual Uses mean uniqueness [r(60) = .308, *p*= .016], and Associative Fluency mean uniqueness and Unusual Uses total fluency [r(60) = .390, *p*=.002]).

Table 4-1. Group means and standard deviations (SD) for language and cognitive measures

Measure	Older Adults		Younger Adults	
	Mean	SD	Mean	SD
WAIS-R vocab	49.50	6.62	44.73	8.98
Audit. Naming	38.80	1.96	36.50	2.74
OSPAN	29.73	11.40	33.40	12.38
SNST	96.89	42.93	47.67	17.07

Table 4-2. Principal component analysis for cognitive and verbal factors

Measures	Component 1	Component 2
WAIS-R vocab	.832	-.117
Audit. Naming	.847	.093
OSPAN	.237	-.767
SNST	.205	.800

*Rotation Method: Varimax with Kaiser Normalization.

Table 4-3. Group means and standard deviations (SD) for experimental creativity tests

Measure	Older Adults		Younger Adults	
	Mean	SD	Mean	SD
Unusual Uses				
Mean Uniqueness	.40	.10	.34	.10
Total Fluency	26.43	11.36	26.97	12.29
Associative Fluency				
Mean Uniqueness	.48	.10	.40	.13
Total Fluency	63.43	37.66	83.90	74.78
WAIS-R Similarities	22.70	3.98	19.07	5.16
Remote Associates Test	11.17	3.16	9.83	3.72
Storytelling Scores				
Cohesion	4.18	.63	4.38	.63
Organization	3.33	.93	3.63	.88
Appropriateness	4.63	.47	4.85	.30
Uniqueness/Originality	2.94	.84	3.69	.85
Overall	2.82	.67	3.48	.74

Table 4-4. Correlations between story telling scores and language measures

Measure	Correlation Significance	1	2	3	4	5	6	7
WAIS-R vocab (1)	r	1	.461**	.199	.281*	.064	.008	.112
	p		.000	.142	.036	.639	.955	.413
Aud. Naming (2)	r		1	.069	.164	.029	-.082	-.006
	p			.612	.227	.835	.549	.965
Cohesion (3)	r			1	.598**	.196	.017	.237
	p				.000	.147	.900	.079
Organization (4)	r				1	.318*	.055	.340*
	p					.017	.688	.010
Appropriate (5)	r					1	.299*	.439**
	p						.025	.001
Uniqueness (6)	r						1	.917**
	p							.000
Overall (7)	r							1
	p							

Table 4-5. Correlations between story telling scores and cognitive measures

Measure	Correlation Significance	1	2	3	4	5	6	7
SNST (1)	r	1	-.238	-.059	-.242	-.231	-.469**	-.499**
	p		.073	.671	.078	.092	.000	.000
OSPAN (2)	r		1	.183	.223	.190	.042	.116
	p			.177	.099	.161	.759	.395
Cohesion (3)	r			1	.598**	.196	.017	.237
	p				.000	.147	.900	.079
Organization (4)	r				1	.318*	.055	.340*
	p					.017	.688	.010
Appropriate (5)	r					1	.299*	.439**
	p						.025	.001
Uniqueness (6)	r						1	.917**
	p							.000
Overall (7)	r							1
	p							

Table 4-6. Correlations between creativity tests and language measures

Measure	Correl. Signif.	1	2	3	4	5	6	7	8
WAIS-R vocab (1)	r	0001	.461**	.296*	.555**	.099	-.012	.156	.144
	p		.000	.021	.000	.453	.925	.233	.274
Aud. naming (2)	r		1	.371**	.476**	-.054	.036	.117	.120
	p			.004	.000	.680	.788	.375	.361
RAT (3)	r			1	.323*	-.140	.055	.122	.026
	p				.013	.288	.674	.355	.846
WAIS-R Similar (4)	r				1	.043	-.012	.113	.273*
	p					.750	.926	.398	.038
AF mean unique (5)	r					1	.503**	.426**	.390**
	p						.000	.001	.002
AF total Fluency (6)	r						1	.308*	.556**
	p							.016	.000
UU mean unique (7)	r							1	.299*
	p								.020
UU total Fluency (8)	r								1
	p								

Table 4-7. Correlations between creativity tests and cognitive measures

Measure	Correl. Signif.	1	2	3	4	5	6	7	8
SNST (1)	r	001	-.238	.072	.227	.123	-.276*	.039	-.215
	p		.073	.592	.093	.358	.036	.771	.104
OSPAN (2)	r		1	.054	.242	.179	.194	.061	.332**
	p			.684	.068	.171	.137	.644	.010
RAT (3)	r			1	.323*	-.140	.055	.122	.026
	p				.013	.288	.674	.355	.846
WAIS-R Similar (4)	r				1	.043	-.012	.113	.273*
	p					.750	.926	.398	.038
AF mean unique (5)	r					1	.503**	.426**	.390**
	p						.000	.001	.002
AF total Fluency (6)	r						1	.308*	.556**
	p							.016	.000
UU mean unique (7)	r							1	.299*
	p								.020
UU total Fluency (8)	r								1
	p								

Table 4-8. Correlations between story scores and divergent creativity tests

Measure	Corr. Signif.	1	2	3	4	5	6	7	8	9
Cohesion (1)	r	1	.598**	.196	.017	.237	-.300*	-.183	-.276*	-.328*
	p		.000	.147	.900	.079	.024	.177	.039	.014
Organization (2)	r		1	.318*	.055	.340*	-.309*	-.043	-.218	-.144
	p			.017	.688	.010	.021	.752	.107	.290
Appropriate (3)	r			1	.299*	.439**	-.222	.189	-.058	.202
	p				.025	.001	.100	.163	.672	.135
Uniqueness (4)	r				1	.917**	-.137	-.069	-.122	.148
	p					.000	.313	.611	.369	.277
Overall (5)	r					1	-.158	-.036	-.181	.098
	p						.244	.794	.182	.471
UU mean unique (6)	r						1	.299*	.426**	.308*
	p							.020	.001	.016
UU total fluency (7)	r							1	.390**	.556**
	p								.002	.000
AF mean unique (8)	r								1	.503**
	p									.000
AF total fluency (9)	r									1
	p									

Table 4-9. Correlation between story scores and convergent creativity tests

Measure	Correl. Signif.	1	2	3	4	5	6	7
Cohesion (1)	r	1	.598**	.196	.017	.237	.047	-.001
	p		.000	.147	.900	.079	.729	.994
Organization (2)	r		1	.318*	.055	.340*	.048	-.051
	p			.017	.688	.010	.728	.716
Appropriate (3)	r			1	.299*	.439**	.080	.091
	p				.025	.001	.558	.514
Uniqueness (4)	r				1	.917**	.014	-.004
	p					.000	.917	.979
Overall (5)	r					1	.053	-.030
	p						.699	.827
RAT (6)	r						1	.323*
	p							.013
WAIS-R Simil. (7)	r							1
	p							

Table 4-10. Correlations among creativity tests

Measure	Correl. Signif.	1	2	3	4	5	6
RAT (1)	r	1	.323*	-.140	.055	.122	.026
	p		.013	.288	.674	.355	.846
WAIS-R Simil (2)	r		1	.043	-.012	.113	.273*
	p			.750	.926	.398	.038
AF mean unique (3)	r			1	.503**	.426**	.390**
	p				.000	.001	.002
AF total fluency (4)	r				1	.308*	.556**
	p					.016	.000
UU mean unique (5)	r					1	.299*
	p						.020
UU total fluency (6)	r						1
	p						

CHAPTER 5
DISCUSSION

The purpose of this study was to investigate creative verbal processing and assess how those processes were affected by healthy aging. It has been suggested that there are a number of processes involved in creative processing; these include divergent processing, convergent processing and associative processing. The processes are thought to rely on, or use similar resources to, different forms of cognitive processing. Divergent processing is thought to rely heavily on frontal functions such as disengagement, convergent processing on domain-specific knowledge and associative processing is thought to rely on knowledge of semantic relationships.

We had predicted that our older adult participants would perform more poorly on tasks requiring frontal functions since it is known that older adults show deficits in a number of tasks assessing frontal functions. We predicted that older adults would perform as well as or better than younger adults on a convergent task, but only if the task required processing previously learned concepts. We also predicted that older adults would perform more poorly on associative tasks. Although older adults generally have larger vocabularies indicating a greater number of semantic representations, they are also known to have decreases in inter and intra-hemispheric connectivity which could affect ability to access associations across a wide network of semantic relationships on demand. Finally, we predicted that our older adult participants would have poorer scores in a task of creative production which required the use of all the types of processes. We also wanted to examine the relationships among the tests used in this experiment as well as their relationship to standard language and cognitive measures.

Divergent Processing

The first test we used to assess divergent processing was the Unusual Uses Test. Previous research has shown age-related decline in verbal fluency in older adults on many semantic fluency type tasks (Kozora & Cullum, 1995; Troyer, Moscovitch, & Winocur, 1997). However, no significant difference was found in number of overall responses between younger and older adults. In addition, we found that the older adults produced more unique responses than did the younger adults, a finding we had not predicted. When we covaried with the verbal and cognitive factors, the cognitive factor had a significant predictive effect on performance on fluency on this test. Subsequent correlational analysis showed a highly significant correlation between fluency on this measure and working memory (i.e., performance on the OSPAN). This indicates that ability to produce a large number of responses on this test was dependent in part on working memory.

The findings for this divergent test contrast in some ways with the findings for our second divergent measure, the Associative Fluency task. The main finding, that older adults produced more unique responses was found in both tests. Where the results varied was in the correlations with cognitive ability. For the Associative Fluency task, it was disengagement (as measured by the SNST) that was correlated with fluency, rather than working memory. We believe that the difference in findings between correlations for fluency may be influenced by the nature of the divergent tasks required. The first test, Unusual Uses, required the respondent to think of uses for an object. Answers tended to be anywhere from five to fifteen words apiece and were often phrased in terms of actions the participant remembered using the object for (e.g., “I have used a toothpick to make a stake for a new tomato plant…”). Strategic search processes may be important in this task (Bryan & Luszcz, 2000) and it is likely that this test required activation of larger neural networks than did the Associative Fluency task which required only single word responses. This may explain why working memory was correlated with this task but not with the Associative Fluency task which was less cognitively demanding. Associative Fluency on the other hand, was significantly and negatively correlated with disengagement as measured by SNST, indicating that an ability to disengage was important in producing multiple single word associates. The production of multiple associates for a single word does require an ability to switch between categories, which would require disengaging from a current category, since the number of possible associates in any single category would be limited.

The finding that older adults produced more unique responses on these two measures was not predicted by the authors of this study, and is in contrast with other available research on this topic. In regards to Unusual Uses, there is very little data currently examining age differences on this test. Bryan & Luszcz (2000) do report having found an age difference in performance on this test but it is not clear which possible scoring criteria accounted for this difference. We scored only for uniqueness and fluency for this study but not for perseverations or answers that listed usual rather than unusual responses. There have been a number of studies addressing age differences in Associative Fluency tasks. Lovelace and Cooley (1982) found that high vocabulary scores in both young and older adults were associated with producing more common (i.e., more frequent) responses on word association tasks. We did not find even near significant correlations between vocabulary level and uniqueness scores for our groups. Howard (1980) and Hirsh and Tree (2001) also both report findings that younger adults produced a wider variety of responses, more unique responses, and more instances of providing non-dominant responses. Again, we found that our older adults produced more unique responses. However, our task differed from any others currently found in the literature in that we placed no time constraints on participants and asked them to list all associates they could think of. This difference may account for our findings since it removes speed of processing considerations which are known to affect older adults more strongly than younger adults.

Convergent Processing

Older adults performed significantly better on the convergent processing task, the WAIS-R similarities subtest. Older adults had higher mean scores on the associative convergent task, the RAT, but this difference was only significant when verbal ability was covaried. Convergent processing emphasizes logic, accuracy, and recognition of the familiar and is linked to knowledge since it often involves manipulation of previously acquired information (Cropley, 2006). In the case of verbal convergent processing, the previously acquired information that would be important is language knowledge. We know that vocabulary stays stable or increases with age (Verhaeghen, 2003), a finding verified by our study as well, wherein our older adult participants performed significantly better on both language ability measures (i.e., WAIS-R vocabulary and auditory naming).

Both of the convergent tests correlated significantly with both of the language measures, while none of the divergent measures correlated with the language ability measures. This indicates that the convergent processing tasks were much more dependent on the domain specific knowledge of language, and therefore the older adults' superior language ability allowed them to perform better on these tasks. Both convergent tasks required an ability to find similarity or commonality in words or concepts, an ability that is dependent on knowledge of semantic relationships We predicted that older adults may perform as well as or better than younger adults in a convergent verbal processing task if the relationships were previously learned, which would make a response dependent simply on recalling pre-existing knowledge of learned semantic relationships. The results of our convergent processing tests and the high correlations with language ability measures suggest that these tasks did rely in large part on previously acquired lexical-semantic knowledge. However, if relationships had not been learned, but needed to be formulated, the semantic representations would need to be manipulated to discover how they fit together. The task of associating novel semantic relationships was examined using the verbal production task, short stories.

Creative Verbal Production – Short Stories

This task required participants to create novel associations between unrelated words and use them in a short story. Older adults' stories were scored more poorly in uniqueness, appropriateness and overall score. Without controlling for verbal ability or cognitive skill level, those three categories were significantly different between groups, but cohesion and organization were not. However, when verbal ability was controlled, older adult participants were judged as having performed more poorly on all rating categories.

This finding is in contrast to the finding regarding uniqueness in the divergent tasks where older adults produced more unique responses. We theorize that this difference in uniqueness, or creativity, is due to the novelty of the task. In the divergent tasks described above, participants were asked to produce responses using semantic associates that were previously learned (e.g., that chair is associated with table), although we did ask them to list as many learned associates as possible. In the other task they were asked to describe alternate or unusual uses for common objects that they would have experienced using. Many of the subjects did list uses that they had personally experienced or had witnessed. Even many of the purely imagined uses involved a substitution of an experienced use, for example, using a toothpick to stir (i.e., using it in place of a spoon or stirring straw). Older adults' greater life experiences could be the primary factor resulting in higher uniqueness scores in these divergent tests. They have had time to be exposed to more associates for words and time to be exposed to more uses for common objects. The story task, on the other hand, required formation of completely novel associations.

Older adults' greater lexical-semantic skill as evidenced by performance on vocabulary and naming tests correlated only with organization so did not afford older adults an advantage in this verbal production task. It may be that for a novel creative production task such as this one, it is the ability to make new connections between existing semantic representations that is more important than the number of semantic representations. As mentioned previously, the literature has shown that older adults lose white matter connections in normal aging (Guttmann et al.,1998). Although older adults may have a greater number of semantic representations, and be able to maintain known semantic associations between representations (as is shown by intact processing on mediated priming tasks (Bennett & McEvoy, 1999)), they may have more difficulty making new associations between existing representations.

There is support for the idea that diffuse connectivity of different networks both within hemispheres and between hemispheres is involved in creative production tasks.

Studies investigating the production of stories using associated words (Petsche, 1996) showed that there was an anatomically distributed coherence of left hemisphere EEG oscillations during performance of this task. This indicates that a larger proportion of cortical networks are required to create novel verbal productions than are required for fluency tasks which show strong frontal activation but not as much widely distributed activation.

Other studies have used neuroimaging to examine activation in production tasks of stories using unrelated words or distant associates (e.g., Beeman, 1998; Bekhtereva et al., 2000; Howard-Jones et al., 2005). All of these studies found that the right hemisphere prefrontal cortex was activated when participants were asked to make unusual associations between words or to create stories using semantically unrelated words. However, the same area in right prefrontal cortex is shown to be activated by processing STROOP tasks such as the SNST used in this study. The right activation may be explained by the strong attentional and monitoring demand placed by associating unrelated words (Howard-Jones et al., 2005).

The findings in our study support this commonality between the production of stories using unrelated words and the ability to disengage. The strongest correlations found between any of the scores on the story telling task and the language and cognitive measures was that between the test of disengagement (SNST) and the uniqueness score and the overall score. The greater trouble a participant had with disengaging, the more likely they were to have difficulty creating a story that would be judged as “creative” using novel associations. Uniqueness in divergent tasks did not correlate with the SNST scores. This underscores the probability that, while divergent processing is an important part of creative processing, it is only an element and seemingly, not the element most affected by the changes of normal aging.

The finding that our older participants created stories that were judged more poorly in areas such as cohesion and organization fits with the current literature. Older adults have been shown to make more errors in cohesion in story re-telling tasks (Kemper et al., 1990; Pratt et al., 1989; Juncos-Rabadan, 1996). However, in other studies samples of discourse created by older adults were rated as being more interesting than those created by younger adults (James et al., 1998; Pratt & Robins, 1991). Our study did not support these findings; however, the verbal production task was not the same, in that the previous studies looked personal narratives or unconstrained storytelling, whereas our task required an additional element of associating unrelated words.

Associations Between Types of Processing

As mentioned previously, there are a number of types of processing that have been proposed as being essential to creativity. A secondary purpose of this study was to compare performance on tasks using the different types of processing to see if test scores correlated with similar tests (i.e., does performance on one divergent test correlate with performance on another), as well as to determine if performance correlated with language or cognitive abilities thought to underlie the type of processing.

Our correlational analysis showed that both sets of scores on the divergent tests (i.e., Unusual Uses and Associative Fluency) were all strongly correlated. Likewise, the two convergent processing tasks were also correlated. The two tests that were considered “associative” however, one of which was convergent (i.e., RAT) and one of which was considered divergent (i.e., Associative Fluency) were not at all correlated. These results show that the terms “associative convergent” or associative divergent” may not be real distinctions. The overriding distinction seemed to be whether the task required convergent or divergent processing, rather than whether it required associative processing. However, the role of association in creative processing remains to be more clearly elucidated.

We had predicted that performance on divergent tasks would correlate with performance on a test of disengagement, as both are frontally mediated. Only one of the divergent tasks correlated with our disengagement measure, total fluency on Associative Fluency. Total fluency on Unusual Uses correlated with a working memory tests. We mentioned above that we believe that this difference was due to the complexity of the task, in that the Unusual Uses test was a more cognitively complex task. In contrast, the convergent tests did both strongly correlate with both of the language ability measures as predicted. Additionally, we had predicted that high scores in uniqueness on divergent tests would predict high scores in uniqueness/originality on the story telling task. This prediction was not borne out by our data. We believe this difference was due to the fact that the stories required the formation of new associations, rather than recall and production of previously learned associations.

Conclusions

The primary purpose of this study was to investigate verbal creative processing in normal aging. We had predicted that older adults would perform more poorly on almost all tasks. What we found was that older adults, in fact, performed better than younger adults on many of the tasks. This finding was surprising, especially since it also did not seem to match the level of performance shown by older adults in a story telling task, as we had also predicted. We believe this difference is due to novelty. Older adults were able to associate widely and produce a great range of responses when the associations between the concepts was known, but not as easily when the task required forming new associations. Creativity is, by most accepted definitions, the production of something both novel and appropriate. Therefore, by this criterion, we did find that older adults were less able to produce creative verbal productions that were judged as being unique and appropriate.

There is now considerable literature stating that learning can occur throughout our lifetime, even into old age (Glisky & Glisky, 2008) and that learning something new as we age may be even more important than practicing previously acquired skills or knowledge. Learning new information or a new skill can result in the formation of new synaptic connections which may be protective against some of the loss of connectivity seen in the normally aging brain. Most of the older adult participants in this study reported enjoying taking part in the creative processing tests. The use of simple tasks such as the creation of short stories using unrelated words could be an easy and relatively stress free way to boost neuroplasticity in older adults and maintain healthy cognitive and language functioning.

The importance of creating novel or unusual associations in creative processing is a crucial and complex question that could be addressed in future studies. It would seem that since older adults are known to have a deficit in tasks such as the STROOP test which shows activation in the same area also shown to be active in processing novel or distant associates, that older adults' difficulty with processing novel associates is due to difficulty disengaging. However, studies so far that have shown increased right prefrontal activity have all used divergent processing tasks. It is unclear whether a convergent associative task using unusual associates (such as the RAT) would also result in increased right prefrontal activity. This test did require processing unusual associates and in our study, older adults performed slightly (although not significantly) better on this test. If convergent processing of distant or unusual associates did also activate right prefrontal, it would suggest that the recruitment of those areas in processing associates is not necessarily where the deficit lies for older adults. An imaging study comparing convergent processing and divergent processing of unusual or novel associations in younger and older adults could shed some light on the source of difficulty of creating novel associations for older adults.

APPENDIX A
STORYTELLING CATEGORY DEFINITIONS

- Novelty/Originality – this rating refers to whether the story uses ideas that are generally not produced, or ideas that are totally new or unique (based on Torrance, 1974)
- Cohesiveness – this rating is an assessment of whether the story makes correct use of cohesive devices such as pronouns, conjunctions, and determiners. (For instance, are there pronouns with no referent noun?)
- Organization – This rating is used to judge the overall structure of the story. (For instance, does the story have a recognizable beginning and end? Are sentences left unfinished or grammatically incorrect?)
- Appropriateness – this rating refers to whether the story makes sense or, in contrast, whether the participant strung the provided words together in a haphazard fashion without attempting to create a real story.
- Overall score – This rating is intended to elicit the judges' overall impression of the story as a whole

APPENDIX B
CRITERIA FOR STORY RATINGS

Appropriateness: Does the appropriately use all 3 words in their correct form and did the participant make an effort to incorporate all words appropriately into the story or were they used haphazardly? Participants may change the order of the words but not the form (e.g., no plurals or adding "ing"). Ratings refer only to the criteria set out below, even if organization and/or cohesion is poor for this story.	
5	All 3 words are in their correct form and are appropriately incorporated into the story
4	1 word is incorrect but is appropriately incorporated OR 1 word is not appropriately incorporated (is haphazardly used) but is in its correct form
3	2 words are incorrect but are appropriately incorporated OR All words are correct but are not appropriately incorporated (they are haphazardly strung together)
2	2 words are incorrect and are not appropriately incorporated
1	No words are correct and no effort was made to incorporate them into the story.

Cohesion: Does the story make correct use of cohesive devices such as pronouns (he, she, it), conjunctions (and, or, yet) and determiners (this, that)?	
5	No cohesion errors.
4	1 minor cohesion error (e.g., pronoun does not refer back to antecedent) but it does not affect comprehensibility of story
3	1 major cohesion error that affects comprehensibility of story
2	2 cohesion errors
1	3 or more cohesion errors

Organization: Does the story structure have a clear beginning and end, appropriate use of grammar, complete sentences, and self-corrections or interjections?	
5	Story has a clear beginning and end, no grammatical errors, no unfinished sentences, no self-corrections or interjections
4	1 organizational error
3	2 organizational errors
2	3 organizational errors
1	More than 3 organizational errors

Novelty/Originality: Does the story use less common ideas or incorporate elements that are new or unique?	
5	Story is highly original and incorporates ideas in a unique way
4	Story is somewhat original and some ideas are unique
3	Story is average
2	Story is not very original and few elements are unique
1	Story is completely unoriginal and forgettable

Overall Impression:	
5	Very impressed, scores high on all criteria
4	Somewhat impressed, scores high on most criteria
3	Average
2	Somewhat unimpressed, scores low on most criteria
1	Very unimpressed, scores low on all criteria

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BIOGRAPHICAL SKETCH

Susan Leon received an undergraduate degree in Russian in 1995 from the University of Florida. After a brief stint in business, she returned to school and earned a post baccalaureate degree in linguistics. She then went on to receive a master's degree in communication sciences and disorders. Following graduation from the master's program she began work as a research speech pathologist at the Veteran's Administration (VA) Brain Rehabilitation Research Center at the Malcom Randall VA Medical Center in Gainesville Florida. She returned to the University of Florida in 2001 to begin doctoral work. Her research interests focus on problems of communication and cognition affecting adults, with a special emphasis on individuals with Alzheimer's disease. She received her doctorate from the department of Speech, Language and Hearing Science in 2010.