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Divergent Task Performance in Older Adults: Declarative Memory or Creative Potential?

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Abstract

Divergent thinking is the ability to produce a range of responses or solutions and is an element of creative processing. Divergent thinking requires disengagement, the ability to associate between words or ideas, and the production of responses. Lesion and imaging studies have shown frontal-lobe involvement for these activities, and frontal lobe function is highly dependent on white matter pathways. Normal aging often results in deficits in functions controlled by the frontal lobes as well as decrements in white matter connectivity. The objectives of this study were to compare non time-constrained tasks of verbal divergent processing in young adults (YAs) and older adults (OAs) and correlate performance with tasks of working memory, language ability, and disengagement/inhibition. Participants were 30 YAs and 30 OAs. Contrary to the a priori hypothesis, OAs produced significantly more unique responses than YAs, although total fluency was not significantly different. Correlational analyses examining the groups together and separately revealed a number of differences suggesting that the groups were utilizing different underlying cognitive abilities to complete these tasks. The authors propose that the primary factor resulting in higher uniqueness scores for the OAs was a greater wealth of experience as well as longer exposure to language use.

Introduction

Creativity is the ability to understand, develop and express novel orderly relationships (Heilman, 2005). The production of novel and innovative ideas requires the manipulation of knowledge (Nickerson, 1999); verbal linguistic creativity requires manipulation of our knowledge of words and language. Throughout our lifespan, humans develop stores of semantic representations for the objects, actions, and concepts that are encountered. These representations are stored in neuronal networks which encode information about how a particular object looks, feels, smells, tastes, and sounds (Collins & Loftus, 1975). Neuronal networks also encode and store information about the associations between semantic representations, actions of given objects, how an object or idea makes us and others feel, as well as memories of our encounters with objects, actions and concepts (Barsalou et al., 2003). Our brain encodes information about the series of speech sounds (phonemes) or letters (graphemes) that represent the words that symbolize these objects, actions and concepts as well as information about how phonemes or graphemes are produced (Nadeau, 2001). These lexical-semantic networks are dependent upon millions or even billions of neural interconnections, and it is these networks, as well as our knowledge of how language is structured that is the basis for human's linguistic ability.

There have been many models proposed over the last century for how creative thinking takes place. One of the earliest and most influential models was proposed by Wallas in 1926. It delineated four main phases of creativity: Preparation, when the individual focuses on the problem and acquires the skill or knowledge necessary to solve it; Incubation, when the mind is focused away from the problem in a low arousal or relaxed state of mind and processing of the problem is performed subconsciously, (Intimation, a feeling that a solution is imminent is considered a sub-stage of Incubation); Illumination, or the "eureka" moment when a possible solution reaches consciousness; and finally verification, when the solution or idea is verified or validated for appropriateness. This model spawned other models that attempted to elucidate the subconscious phases. Rossman (1931) expanded Wallas' model based on responses to questionnaires he received from hundreds of inventors. He proposed seven steps including, Observation of a need, Analysis of the need, Survey of all information, Formulation of solutions, Critical analysis of solutions, Birth of the new idea and finally Experimentation to find the best solution. Osborn (1953) who developed the concept of "brainstorming" also proposed a seven step model which was quite similar to Rossman's and included: Orientation to the problem, Preparation to gather pertinent data, Analysis to break down the relevant material, Ideation to gather new alternatives, Incubation to allow illumination, Synthesis to put the pieces together, and Evaluation to judge the resulting ideas. Guilford (1950; 1967) a psychologist known for his work in intelligence and creativity testing, introduced the concepts of divergent thinking and convergent thinking as cognitive processes essential to creative production.

The proposed models differ in some respects but overlap in more. In all the models mentioned above there is an initial stage requiring preparation, observation and analysis. Weisberg (1999) in a review of research related to knowledge and creativity argues that knowledge in a given discipline provides the building blocks necessary for creative achievement. Both qualitative and quantitative studies of the productions of creative

individuals have shown that an extensive amount of time is required for acquiring domain specific knowledge before significant creative works are produced (Weisberg, 1999). This knowledge is necessary for the initial preparatory stage. The next stage common to the models is the ideation or innovation stage involving the formulation of new solutions. This stage of ideation or innovation is dependent upon divergent thinking which, in turn, is composed of several elements. The first element of divergent thinking is conceptual disengagement, the ability to break away from standard or prepotent responses. The next element of divergent thinking is the development and production of alternative ideas or responses. The ability to associate between words, objects, images or ideas is vital to the development of alternative ideas (Mednick 1962; Benedek, Könen, & Neubauer, 2012). The final stage involves convergent thinking which is the ability to find or identify the correct or most appropriate response or answer. This stage involves synthesizing and critical analysis of possible solutions, and verification or evaluation that the solution generated in the preceding stage is appropriate. Whereas all of the described stages play important roles in creative production, divergent thinking has been the focus of many studies investigating creative processing and has often, incorrectly, been equated with creativity (Runco, 2008). Divergent tasks may indicate potential or estimates of likely creative behavior but are not alone sufficient for creative processing (Runco, 1991)

Psychometric and Neuropsychological Testing of Creative Processing

Psychometric assessment of creativity began in earnest in the mid 1900's and often focused on tests of divergent thinking (Plucker & Renzulli, 1999). Divergent thinking ability was assessed in a number of ways and most often required the production of a number of responses, as opposed to "traditional" tests which usually required a single correct response. This led to an emphasis on ideational fluency in assessing divergent thinking. Some the best known divergent thinking tests were Guilford's Structure of the Intellect (1967), and Torrance's Test of Creative Thinking (1974). Another test that has been used extensively is the Alternate Uses test, also known as the Unusual Uses test (Guilford, Christensen, Merrifield, & Wison, 1978). The Alternate Uses test asks respondents to name all the alternate or unusual uses they can imagine for a common object (e.g., a brick). Responses can be analyzed in for fluency (number of responses produced), flexibility (number of categories responses fell into), and originality (or uniqueness). Flexibility has been shown to be linearly related to originality for this test (Reese, Lee, Cohen & Puckett, 2001) and as such may be a redundant outcome measure.

Lesion studies as well as functional imaging studies suggest that the frontal lobes are important for divergent processing (Damasio & Anderson, 2003; Carlsson, Wendt, & Risberg, 2000). A number of frontally mediated executive processes have been posited to be involved in divergent thinking including ability to disengage from a prepotent response or a previously used strategy (also commonly referred to as set-shifting), inhibition, and the development of alternative strategies to produce responses (Heilman, Nadeau & Beversdorf, 2003). The ability to disengage primarily relies on functions of the frontal lobes, an idea first put forth by Denny-Brown and Chambers (1958). They noted that all animals, from simple single-celled animals to humans, are capable of two types of actions, approach and avoidance. The posterior portions of the brain's cerebral cortex (such as the posterior

temporal and parietal regions) are important for approach and attachment, while the more anterior regions, such as the frontal lobes, are important for avoidance and disengagement. Tests such as the Wisconsin Card Sorting Test (WCST), which requires an ability to switch from one response set to another, have commonly been used to assess disengagement in the visuospatial domain (Craik et al., 1990). Evidence for frontal involvement in this test comes from regional blood flow studies showing increased blood flow in the frontal lobes when normal adults perform this test (Weinberger, Berman, & Zec, 1986), and from studies of individuals with frontal lobe injury who show decrements in performance (Milner, 1963). There are many versions of the Stroop test (Ridely, 1935), wherein respondents are asked to name the color of the colored font used to print words of colors, when these words are incongruent with color of the font (e.g., the word “red” written in blue ink), and these may also be used to assess ability to disengage from a prepotent response as well as inhibition.

The productive aspect of divergent thinking has often been measured by fluency, or the number of responses given as well as originality. Associative fluency tasks, such as described by Christensen and Guilford (1957), require a spread of activation within the semantic-lexical network from one word to another conceptually related word (Collins & Loftus, 1975). In an associational fluency task the participant is given a series of words and after each word is presented the participant is told to list other words that could be associated (related) with this target word. Performance on this type of task is thought to be heavily reliant on cortical connectivity and the degree to which excitability spreads in the semantic-conceptual network (Vandenberghe et al., 2012). Lexical-semantic entities that are closely related have strong connectivity and those that are more remotely related have weaker connectivity (Collins & Quillian, 1972). Thus, the primary postulate underlying such tasks is that more extensive intracortical connectivity would allow a greater spread of excitation and should result in the production of unusual or novel responses. In a study examining the relationship between white matter integrity and creative processing using diffusion tensor imaging, fractional anisotropy measures in pathways involving association cortices and the corpus callosum found that greater white matter structure integrity was significantly related to performance on divergent tasks in healthy adults (Takeuchi et al., 2010).

Verbal Creative Processing in Aging

Creative processing ability has been commonly reported to decline with advancing age (Simonton, 1999) and this decline has been thought to be related to a decline in divergent thinking ability. As mentioned, the frontal lobes are critically involved in divergent thinking and show the steepest rate of atrophy in normal aging (Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003). There is also a decrement in white matter connectivity in normal aging (Guttman, et al., 1998; Pfefferbaum et al., 2000) and normal frontal lobe function is highly dependent on white matter pathways including both cortical-subcortical (e.g., frontal-basal ganglia, thalamic, frontal circuits), and cortico-cortical connections from portions of the limbic system and temporoparietal cortex. The anatomic changes that occur in aging are associated with declines in frontally mediated tasks (Craik, Morris, Morris, & Loewen, 1990; Moscovitch & Winocur, 1995; Bryan & Luszcz, 2000).

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 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 lexical-semantic representations.

Age-related declines in verbal fluency performance have been reported (Brickman et al., 2005; and Van der Elst, et al., 2006) with greater declines seen for categorical than phonemic tasks (Brickman et al., 2005). Imaging studies of overt fluency tasks show that older adults recruit more frontal, temporal and parietal regions to perform these tasks than do younger adults (Brown et al., 2005; Soros et al., 2011) which may be related to compensation for age-related declines. Studies investigating associative verbal fluency in aging have examined number of responses as well as frequency or commonness of the response. Howard (1980) examined variability of responses when older adults generated properties of a stimulus word and found that older adults produced fewer unusual or unique responses. 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 unusual or unique responses, and more instances of providing non-dominant responses. These findings could indicate that the spread of associative activation is narrowed in normal aging, such that fewer remote associates for a given word are available. However, with aging there is also a well-documented slowing of response times (Salthouse, 1985) and the above mentioned studies were either timed or examined only a limited number of responses for each stimulus word. Therefore it is unknown how slowed response times may affect performance for older adults in these tasks.

Previous studies have also reported declines in the performance of older subjects' performance on divergent processing tasks (McRae, Arenberg & Costa, 1987, Ruth & Birren, 1985); however, more recent studies have clouded this picture. In a retrospective study of divergent processing tasks, Reese and colleagues (2001) examined differences in performance on word association and alternate uses tasks among four age groups. They found that the groups did not differ significantly in fluency on a timed associational fluency task, but did not examine the originality or uniqueness of responses on the associational fluency task. There were also no significant age group differences in fluency scores on the alternative uses test. Originality was scored on this task and was found to be significantly lower only for the oldest participants (over age 75). Another study which removed speed of processing effects by giving untimed versions of common divergent processing tests reported no significant age differences in fluency, but did not examine originality or uniqueness of responses between younger and older adults (Foos & Boone, 2008).

Aims of the Current Study

The primary aim of the current study was to examine age differences in both fluency and originality-uniqueness in verbally-based divergent tasks using non time-constrained versions. It was hypothesized that older adults would produce fewer unique responses on divergent tasks due to decrements in frontal functioning as well as white matter integrity. The secondary aim was to examine how cognitive and verbal abilities tested in this study correlated with performance on divergent tasks and whether the correlations differed by age group.

Methods

Participants

The participants were 30 healthy younger adults (YAs) aged 18–30 (mean 20.21, SD 1.88) and 30 healthy older adults (OAs) aged 65–80 (mean 72.93, SD 4.99). The OAs had a mean number of years of education of 17.23 (SD 3.56) and YAs had a mean of 14.27 (SD 1.17). Healthy younger adult participants were recruited from undergraduate and graduate 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. Participants were all 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. This study was submitted to and approved by the University of Florida Gainesville Health Science Center Institutional Review Board (IRB-01). Individuals with a history of traumatic brain injury, stroke, neurological disease or chronic medical illness that can result in vital organ failure or any history of developmental disorders (e.g. dyslexia) were not included in this study due to potential differences in cognitive and language functioning. Individuals scoring at 11 or above on the Beck Depression Inventory (Beck, 1987) and older adult with scores ($\leq$ 25) on the Mini Mental Status Exam (MMSE, Cockrell & Folstein, 1988) were also excluded.

Apparatus and Procedures

Language, Inhibition and Memory Testing—Lexical-semantic knowledge was assessed using two tests, the WAIS-R vocabulary (Wechsler, 1981) and a 40 item measure of naming to definition based on normative data found in the work of Hammeke and colleagues (2005). Working memory was assessed using an operation span (OSPAN) task (Turner & Engle, 1989). Disengagement/inhibition was assessed in a verbally based task, the Stroop Neuropsychological Screening Test (SNST) (Trenerry, Crosson, DeBoe, & Leber, 1989). The SNST requires the participant to read aloud a list of words of the names of colors printed in a different color than the name (e.g. the word “blue” written in red ink.) The participant is then given a second list of words and asked to say aloud the color in which the word is printed (i.e., the color of the font). An interference score is the difference in seconds between time taken to read the first set of words, and time taken to name the color of the font in the second task. A higher score indicates a greater level of interference from the prepotent response. This method of scoring the task was chosen over evaluating the number

of words read or colors named in a certain time (e.g., 60 seconds) to limit speed of performance effects.

Divergent Thinking Tasks—Two verbal tasks of divergent thinking were used in this study.

1. The first was the Alternate Uses (AU) test (Guilford, et al., 1978) which was designed to assess flexibility, originality, elaboration and fluency. The participants listed as many “alternate or unusual” uses as they could imagine for five common objects: brick, pencil, paperclip, toothpick, and a sheet of paper. Object names were presented to the participants one at a time. No time limits were imposed; all participants were encouraged to give all responses that came to mind. All participants were given one prompt (e.g. “Can you think of any other uses?”) for each item when they stopped responding a first time, and were given the next word when they verbally indicated a second time that they were done responding. The AU test was scored on two variables, total number of responses (i.e., fluency) and uniqueness (i.e., originality) of each response.
2. The second task utilized Associative Fluency (AF) as described by Christensen and Guilford (1957); however, no time limits were imposed in this study. Each participant was given five words (table, run, door, freedom and hand), one at a time, and told to list all the words he or she could think of that were associated with the target word. They were instructed not to limit themselves, but to list all possible associates that came to mind. All participants were given the same prompt as above one time, and the trial was concluded as above. AF was also scored on two variables, total number of responses and uniqueness of each response.

Both tasks were audio recorded and later transcribed. All responses were then reviewed by a group of four raters. Appropriateness is an important aspect of the whether a response should be considered truly unique or original or just unusual. Unusual behavior and responses are often encountered in individuals with mental illnesses such as schizophrenia, and an unusual response, if inappropriate to a given question, could be irrelevant. Any item that was possibly inappropriate (e.g., listing an alternate use for a paperclip as something to eat) was discussed. If all raters agreed that the response was inappropriate it was removed. The number of responses removed was minor, accounting for less than 1 percent of total responses. After all responses for all participants had been transcribed, the uniqueness of each response was calculated. 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., using a brick to break a window had a frequency score of .055), whereas a more unique response had a higher value (e.g., using a brick as an anchor had a frequency score of .25). A response that occurred only once had a value of 1 (e.g., using a brick to grind spices). Therefore, a higher uniqueness score was indicative of greater uniqueness of a response within the corpus as a whole.

Results

Group Comparisons on Tests of Language, Inhibition and Memory

Older and younger adult participants' means scores and standard deviations for performance on these tasks are shown in Table 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 the test of disengagement/inhibition, the Stroop Neuropsychological Screening Test (SNST) [$F(1, 59) = 33.76, p < .001$], but no significant difference was found between the groups on the working memory task, Operation Span (OSPAN), [$F(1, 59) = 1.42, p = .24$].

Divergent Thinking

Alternate Uses (AU)—A multivariate analyses of variance (MANOVA) with age group (young vs. old) as the between-subjects variable and total fluency and mean uniqueness as the dependent variables were used to compare performance on the AU and AF tasks. Since our OA participants were both more highly educated as a group and performed significantly better on both of the lexical-semantic tests, multivariate analyses of covariance (MANCOVA) were also run with age group (young vs. old) as a between-subjects variable and total fluency and mean uniqueness as the dependent variables with the lexical-semantic tests as covariates to compare performance while controlling for the level of verbal skill. The lexical-semantic tests were very similar in terms of the underlying ability tested by each, thereby increasing the likelihood of collinearity. Consequently, the scores were submitted on the lexical-semantic tests to a principal components analysis with Varimax rotation. The factor analysis showed that both tests loaded on a single lexical semantic factor. This lexical semantic factor was subsequently used as a covariate in the multivariate analyses of covariance. Means and standard deviations for both the divergent and convergent processing tasks are shown in Table 2. The MANOVA for the AU test showed only a trend toward main effect group significance [$F(1, 58) = 2.90, p = .06$, partial $\eta^2 = .092$]. However, the univariate tests showed a significant group effect for uniqueness [$F(1, 58) = 5.026, p = .02$, partial $\eta^2 = .080$] $d = .610$, $CI_{.95} = .585, .635$, but not for total fluency [$F(1, 58) = .03, p = .862$, partial $\eta^2 = .001$]. On the MANCOVA, the lexical semantic factor showed no significant multivariate effects on overall performance [$F(1, 53) = .30, p = .74$, partial $\eta^2 = .011$] or 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 $\eta^2 = .007$].

Associative Fluency (AF)—The MANOVA showed a highly significant main effect for group [$F(1, 58) = 8.90, p < .001$, partial $\eta^2 = .238$]. The univariate tests again revealed a significant group effect for mean uniqueness [$F(1, 58) = 6.03, p = .017$, partial $\eta^2 = .094$] $d = .702$, $CI_{.95} = .673, .730$, but not for total fluency [$F(1, 58) = 1.79, p = .186$, partial $\eta^2 = .030$]. On the MANCOVA, the multivariate tests showed no significant multivariate effect of the lexical-semantic tests on overall performance [$F(1, 58) = 2.05, p = .14$, partial $\eta^2 = .072$] nor 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 $\eta^2 = .000$].

Correlations

YAs and OAs Examined Together—Pearson correlation coefficients were used to indicate the association with the alpha for statistical significance set at $p < .05$. A number of significant correlations were found when looking at the two groups together on measures of divergent processing and tests of lexical-semantic ability, disengagement/inhibition (SNST), and working memory (OSPAN). Regarding divergent processing, total fluency on the AU task was significantly correlated with performance on the OSPAN and total fluency on the AF task was significantly and negatively correlated with performance on the SNST. (See Table 3 for all correlations on divergent tasks).

YA and OA Groups Individually—When the analyses were run separately by group, the correlations changed. The YAs did not show any significant correlations between divergent tasks and measures of lexical-semantic ability, disengagement/inhibition (SNST), or working memory (OSPAN). However, the OAs showed significant correlations between fluency for both measures (AF and AU) and WAIS-R vocabulary, and the AF fluency score was significantly correlated with the working memory measure, OSPAN. For OAs, mean uniqueness on both the AU and AF tasks was significantly correlated with working memory.

In the group correlation, the SNST score was significantly and negatively correlated with fluency on the AF task, however, this effect was not seen when the two groups were examined individually, although there was a trend towards significance in the YAs. Similarly, the significant correlation between total fluency on the AU task and working memory also did not reach significance for either group individually but both showed trends towards significance. These differences in correlations were likely due to the high degree of variability in both samples for these tasks since as sample size decreases, the effect of variability increases. Since these tasks were untimed, there was a high degree of natural variability in number of responses given. When using untimed measures, it may be best to allow individuals to respond at their own pace, but then use a window (e.g. 2 minutes) of response time to compare responses to limit the high variability in completely untimed responding.

Discussion

The first aim of this study was to examine age differences in fluency and uniqueness of responses on two verbally-based divergent thinking tasks, when no time limits were imposed. Some previous studies had reported that older adults were less likely to produce unique responses in divergent tasks (McRae, Arenberg & Costa, 1987, Ruth & Birren, 1985), however, the OAs in this study produced more unique responses. Divergent processing is thought to be heavily reliant on frontally mediated functions such as disengagement and fluency. Deficits in structure and function of the frontal lobes are common in normal aging and because of this age-related degradation of frontal-executive functions, it was had predicted that OAs would have more difficulty producing unique responses in divergent processing tasks. In addition, although OAs usually have larger vocabularies indicating a greater number of lexical semantic representations (as did the older adults in our study), 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.

Despite these age-associated changes in brain connectivity, the older participants in our study were found to have produced a greater number of unique responses in both AU and AF tasks. The mean number of responses (i.e. total fluency) did not differ significantly between groups for either measure, which may be attributable to the lack of time limits in this study which removed speed of processing effects commonly seen when testing fluency in older adults. Because the OA participants were better educated as a group and scored significantly higher on tests of lexical-semantic ability (WAIS-R vocabulary and auditory naming) analyses of covariance were run with lexical-semantic ability as the covariate on the divergent processing tasks. Significant lexical-semantic effects on the divergent processing tasks were not found.

The second aim of the study was to examine how working memory, disengagement/inhibition, and lexical-semantic ability correlated with performance on divergent tasks and whether the correlations differed by age group. Correlational analyses examining the groups together and separately revealed a number of interesting differences. For the divergent tasks, when the correlations were examined on YAs and OAs as a whole, there were only two significant correlations, between AF total fluency and disengagement/inhibition (SNST), and between AU total fluency and working memory (OSPAN). However, when the correlational analyses on the groups were run separately to examine whether lexical-semantic ability or cognitive abilities might differentially affect performance on these tasks by age, neither of the above correlations were found in either group (although there were trends towards significance in both groups for working memory and AU total fluency). No significant correlations were found for the YAs between our lexical semantic measures or cognitive measures and the divergent tasks. The OAs however, showed a number of significant correlations, between AF and AU total fluency and WAIS-R vocabulary performance, and AF total fluency and working memory. Most interestingly, the OAs showed significant correlations for uniqueness scores on both the AF and AU tasks with the working memory measure. Taken together, this suggests that older adults relied more heavily on working memory and lexical access to produce responses in these divergent tasks. The uniqueness scores did not correlate with our measure of disengagement/inhibition in any of the correlational analyses, grouped or separate, suggesting that this was not the critical factor mediating ability to produce unique responses in young or normally aging adults.

In order to explain these results, the authors postulated that the OAs longer lifespan, which would result in a greater accumulation of experiences, could be the primary factor resulting in higher uniqueness scores in the AU and AF tasks. This is in line with findings in previous studies (Runco, Dow, & Smith, 2006; Runco & Alcar, 2010) showing that experience can be related to performance on divergent thinking tasks. OAs are more likely to have been exposed to a greater number of associates for words and more uses for common objects. The AU test was designed to elicit innovative responses, but transcripts of responses revealed that OAs may have been able to produce a larger number of unique responses by using their greater store of life experience. OAs verbalized a purposeful memory search strategy much more often than did YAs. Even many of the imagined uses produced by OAs involved a

stated substitution of an experienced use (for example, using a toothpick to stir in place of a stirring straw). Our results suggest that OAs may be able to excel at these standard divergent thinking tasks by relying on memory and longer life exposure to experiences and language use. In addition, the fact that the OAs in our study were able to produce more unique responses under untimed conditions may be a valuable indicator of the resilience of lexical-semantic ability in normal aging.

Creativity, by definition, requires originality or innovation and it is possible that these common divergent thinking tasks may not be an adequate measure of a person or groups' ability to innovate. It has also been suggested that measuring uniqueness using frequency of occurrence, as is commonly done in studies utilizing these divergent tasks, does not adequately measure originality of a response. A task that required the formation of truly novel associations or responses, as opposed to the tasks used in this study which were able to be completed using declarative memory, may give a better understanding of whether the ability to innovate, and therefore be truly creative, is affected by normal aging.

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TABLE 1

Group Means and Standard Deviations (SD) for Lexical-Semantic and Cognitive Measures

<i>Measure</i>	<i>Older Adults</i>		<i>Younger Adults</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
WAIS-R vocab	49.50 [*]	6.62	44.73	8.98
Auditory 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

Note. OSPAN=Operation span. SNST=Stroop Neuropsychological Screening Test. WAIS-R=Wechsler Adult Intelligence Scale-Revised.

^{*} Difference between groups is significant at the 0.05 level in analysis of variance.

^{**} Difference between groups is significant at the 0.01 level in analysis of variance.

TABLE 2

Group Means and Standard Deviations (SD) for Divergent and Convergent Tasks

<i>Measure</i>	<i>Older Adults</i>		<i>Younger Adults</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
Alternate 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

Note.

* Difference between groups is significant at the 0.05 level in analysis of variance.

** Difference between groups is significant at the 0.01 level in analysis of variance.

TABLE 3
Correlations by Groups for Divergent Tasks Associative Fluency (AF) and Alternate Uses (AU)

			WAIS-R Vocab	Auditory Naming	SNST	OSPAN
YAs and OAs	AF-Total fluency	Pearson correlation	-.012	.036	-.276*	.194
		Sig. (2-tailed)	.925	.788	.036	.137
	AF-Mean unique	Pearson correlation	.099	.054	.123	.179
		Sig. (2-tailed)	.453	.680	.358	.171
YAs	AU-Total fluency	Pearson correlation	.144	.120	-.215	.332**
		Sig. (2-tailed)	.274	.361	.104	.010
	AU-Mean unique	Pearson correlation	.156	.117	.039	.061
		Sig. (2-tailed)	.233	.375	.771	.644
YAs	AF-Total fluency	Pearson correlation	-.123	.106	-.307	-.011
		Sig. (2-tailed)	.518	.577	.099	.955
	AF-Mean unique	Pearson correlation	-.162	-.256	-.016	.146
		Sig. (2-tailed)	.393	.172	.933	.441
OAs	AU-Total fluency	Pearson correlation	-.062	.100	-.247	.326
		Sig. (2-tailed)	.746	.599	.188	.079
	AU-Mean unique	Pearson correlation	-.063	.025	-.018	-.122
		Sig. (2-tailed)	.742	.895	.924	.521
OAs	AF-Total fluency	Pearson correlation	.483**	.253	-.292	.587**
		Sig. (2-tailed)	.007	.176	.132	.001
	AF-Mean unique	Pearson correlation	.301	-.215	-.157	.372*
		Sig. (2-tailed)	.106	.254	.425	.043
OAs	AU-Total fluency	Pearson correlation	.481**	.273	-.312	.340
		Sig. (2-tailed)	.007	.145	.106	.066
	AU-Mean unique	Pearson correlation	.277	-.116	-.252	.364*
		Sig. (2-tailed)	.139	.542	.196	.048

Note. YA=Young adults, OA=Older adults, OSPAN=Operation span, SNST=Stroop Neuropsychological Screening Test, WAIS-R=Wechsler Adult Intelligence Scale-Revised.

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).