Creativity and Working Memory in Gifted Students With and Without Characteristics of Attention Deficit Hyperactive Disorder: Lifting the Mask

C. Matthew Fugate¹, Sydney S. Zentall¹, and Marcia Gentry¹

Abstract
There have been some behavioral indicators and some types of task performance that suggest greater creativity in students with attention deficit hyperactive disorder (ADHD). This evidence would appear counterintuitive given that lower working memory (i.e., holding information in mind for novel recombinations) has often been documented in students with ADHD. Thus, the purpose of this study was to assess working memory and creativity in two groups of gifted students (i.e., with characteristics of ADHD, n = 17, and without ADHD characteristics, n = 20), who were equivalent in fluid intelligence. Significant differences were found indicating that gifted students with ADHD characteristics had not only poorer working memory but also significantly greater creativity than those gifted students without these characteristics. These results were discussed in terms of creative potential, which could serve as an identifier and as a pathway to instruction.

Keywords
creativity, twice-exceptional, special populations/underserved gifted

In 1949, a young man at Eton College had dreams of becoming a scientist. Unfortunately, he was last in his class in biology that year. When he received his report card, his schoolmaster had included the following comments:

His work has been far from satisfactory . . . he will not listen, but will insist on doing his work in his own way. . . . I believe he has ideas about becoming a Scientist; on his present showing this is quite ridiculous, if he can't learn simple Biological facts he would have no chance of doing the work of a Specialist, and it would be a sheer waste of time both on his part, and of those who have to teach him. (Doss & Moore, Anderson Cooper 360°, October 9, 2012)

That young man was Sir John B. Gurdon, winner of the 2012 Nobel Prize in Physiology or Medicine for his groundbreaking work in the area of stem cell research. Ironically, if young John were in school today, it is possible that he would have been referred for testing for attention deficit hyperactive disorder (ADHD) but not assessed for giftedness.

ADHD can be diagnosed based on the level of inattentiveness and/or hyperactivity–impulsivity exhibited (Diagnostic and Statistical Manual of Mental Disorders, fourth edition, Textrevision [DSM-IV-TR]; American Psychiatric Association, 2000), resulting in one of three subtypes: (a) ADHD, predominately inattentive type; (b) ADHD, predominately hyperactive–impulsive type; or (c) ADHD, combined type. Prevalence rates for ADHD reach 8% to 20% of community samples worldwide, with an annual average of 9% of children aged 5 to 17 years (e.g., Akinbami, Liu, Pastor, & Reuben, 2011). The DSM-IV-TR lists characteristics commonly found in children with ADHD, including problems sustaining attention, daydreaming, difficulty listening attentively, difficulty with task commitment and follow-through, lack of attention to detail, difficulty with organization and time management, difficulty sitting still, excessive talking, and often interrupts others. The severity of these characteristics and degree of academic or social impairment places these students along a continuum from clinically diagnosed to those who have characteristics of ADHD and are undiagnosed.

In this introduction, we refer to students across the range of severity as ADHD based on findings that clinic-referred samples and community samples (i.e., selected from behavioral ratings alone) were equivalent in characteristics, outcomes, skill deficits, and responses to intervention (for review and data, see Barbaresi, Katusic, Colligan, Weaver, &

¹Purdue University, West Lafayette, IN, USA

Corresponding Author:
C. Matthew Fugate, Department of Educational Studies, Purdue University, 100 N. University Street, BRNG 5108A, West Lafayette, IN 47907, USA.
Email: fugatec@purdue.edu
Creativity

For decades, researchers have focused on the importance of creativity in education (e.g., Davis, 2004; Guilford, 1967; Lewis, 2009; Renzulli, 1999). Creativity has been documented as a predictor of future performance and success in the workplace (e.g., Tierney, Farmer, & Graen, 1999; Torrance, 1972, 1981) and a factor in healthy emotional development, interpersonal relationships (e.g., Russ, 1998), and career advancements in science, technology, engineering, art, and mathematics (Plucker, Beghetto, & Dow, 2004; Sternberg, 1999). Though there have been many studies focused on creativity, researchers have failed to agree on a definition (Davis, 2004; Plucker et al., 2004). For this reason, we begin with an examination of the personality, behavioral, cognitive, and performance characteristics that are associated with creativity found in the extant literature. From this literature, we will derive an operational definition of creativity as it is will be used in this study.

Associations Between Creativity and Personality/Behavioral Traits

Davis (2004) suggested that personality, cognitive abilities, and biographical traits work together to produce creativity. He conducted an analysis of the creativity literature from 1961 to 2003 with the goal of identifying recurrent personality traits of creative people. Although not all traits applied to all creative people, he identified 22 high frequency traits: 16 positive (e.g., independent, risk-taking, high energy, curiosity, humor, artistic, emotional) and 6 negative (e.g., impulsive, hyperactive, argumentative). This list of characteristics has been followed by reports of an overlap between those individuals with creativity and those with ADHD (e.g., Baum & Olenchak, 2002; Webb et al., 2005). Other researchers have suggested that this apparent overlap could be attributed to the characteristics of giftedness and not by an association with ADHD. That is, students with giftedness may have more difficulty (a) maintaining attention due to an active imagination and a propensity to daydream, (b) completing tasks because of their varied interests, and (c) focusing attention on activities that are not captivating or personally interesting (e.g., Baum & Olenchak, 2002; Cramond, 1994b). Thus, to date, overlapping personality and behavioral characteristics have provided insufficient evidence of an overlap between ADHD and creativity.

Associations Between Creativity and Cognitive Indicators

Creative abilities have also been associated with cognitive traits (e.g., fluency, flexibility, originality, elaboration) and with information-processing abilities (e.g., using existing
knowledge as a basis for new ideas, questioning norms and assumptions, finding problems; Davis, 2004). These information-processing abilities could explain the association often presumed between creativity and highly intelligent individuals. However, some researchers have reported data supporting the threshold theory, which has been defined by findings of a weaker association between creativity and intelligence when overall IQ is above 120 (i.e., assessed by a variety of norm-referenced tests of mental ability) than it is when IQ is below 120 (Getzels & Jackson, 1962; Guilford & Christensen, 1973; MacKinnon, 1962). Also arguing against the relationship between creativity and giftedness is the failure to find differences in the size of the relationship between creativity and intelligence of students above or below the 120 IQ-threshold (i.e., see Preckel, Holling, & Wiese, 2006).

What may explain divergent findings is the failure of these studies to specify and assess the two components of intelligence: crystallized intelligence, which reflects accumulated knowledge, and fluid intelligence, which reflects the ability to flexibly reason, induce rules and patterns, problem-solve, and manipulate new information (Furnham, Batey, Anand, & Manfield, 2008; Preckel et al., 2006).

When fluid intelligence is isolated, there is evidence of an association with creativity and divergent thinking, which are interrelated and needed for problem solving (Batey, Furnham, & Safiullina, 2010; Furnham et al., 2008; Lewis, 2009; Preckel et al., 2006; Silva, 2008). However, there is also a mediating variable between fluid intelligence and the outcomes of creativity and problem solving. This mediator is working memory or the ability to hold information in mind. For example, researchers have found positive associations between working memory and fluid intelligence ranging from .49 to .64 (e.g., Baddeley, 2003; Engle, Tuholski, Laughlin, & Conway, 1999; Hornung, Brunner, Reuter, & Martin, 2011).

Perhaps the ability to hold information in mind allows individuals to reorder elements in new and useful ways, seeing new possibilities and divergent outcomes. This is supported by small to moderate correlations reported between working-memory tasks (e.g., backward digit span, spatial working memory) and reasoning tasks related to creativity (e.g., verbal and figural analogies), with coefficient alphas ranging from .21 to .53 for typical university undergraduates and staff members (Stüß, Oberauer, Wittman, Wilhelm, & Schulze, 2002). More specifically in a review of working memory, as it was related to both analytical and creative problem solving, Wiley and Jarosz (2012) concluded that working memory could have positive and negative influences. Although the ability to narrow and sustain attention to information can be useful during the performance of analytical tasks (e.g., performing sequences of steps in mathematical problem solving or multiple movement possibilities in a problem-solving task), this restricted range of attentional focus can disrupt performance when creative problem solving may be improved by attention to peripheral cues. In sum, the mediating effect of working memory on creativity depends on the type of task to be performed.

**Group Comparisons of Creative Performance**

Typically, creative performance has been operationally defined by tasks assessing originality or the production of divergent strategies and solutions. Using this definition, individuals with ADHD appear to have skills related to generating unique solutions, at least under specific performance conditions and with some tasks. For example, students and/or adults with ADHD and with equivalent intelligence to those without ADHD: (a) told more creative stories with novel themes and plots (Zentall, 1988); (b) used more visual imagery and strategies during problem solving in response to stimulating videos and games (Lawrence et al., 2002; Shaw & Brown, 1999); (c) contributed to higher percentages of correct problem solutions in cooperative groups compared with small groups without a student with ADHD (Kuester & Zentall, 2011; Zentall, Kuester, & Craig, 2011); and (d) performed significantly better than a control group on original idea generation (i.e., divergent from demonstrated exemplars of novel toys), when they were asked to imagine that they worked for a toy company and needed to imagine and draw a new, unique toy within 5 minutes (Abraham et al., 2006). However, when the practicality of idea generation was measured, it was the equivalent-IQ non-ADHD individuals who scored higher and who also preferred clarifying and developing ideas more than the ADHD group, who preferred generating ideas (Abraham et al., 2006).

There are also some tasks and measures that have not produced statistical differences in creative performance. For example, Abraham et al. (2006) made comparisons of clinically diagnosed students with ADHD with typical comparisons without finding creative performance differences on several tasks: (a) fluency or uniqueness differences on an untimed production of alternative and unusual uses of common objects, such as a newspaper or a brick; (b) the ability to extend or loosen preexisting boundaries that required imagining and drawing two new species of animals that might live on a planet wholly unlike Earth (Conceptual Expansion, coded as deviations from representing bilateral systems, common appendages, and features); or (c) the ability to assemble objects (e.g., furniture) using a sequence of threedimensional figures (Creative Imagery). Similarly, Healey and Rucklidge (2005) reported no differences in ideas generated between students with and without ADHD when given a variety of tools and asked to come up with as many ideas as possible as to how they could use these tools to connect the strings (Two-String Problem; Maier, 1931). In general, these tasks were untimed and required using or modifying a sequence of concrete visual structures. It is these types of multiple-component tasks that are more likely to be improved by working memory (for review, see Wiley & Jarosz, 2012), which are different from problem-solving tasks that are
performed better with fewer moves or steps and when ignoring the immediate context and details.

More consistent positive effects have been reported in research investigating divergent thinking and creative achievement in adults with ADHD. White and Shah (2006) reported divergent thinking (alternative and unusual uses of objects) to be associated with medium to large effect sizes for the dependent variables of fluency (d = 0.65), flexibility (d = 0.91), and originality (d = 0.71); divergent thinking was similarly described by Guilford, as early as 1967, with the components of fluency, flexibility, originality, and elaboration. Also, there is recent evidence of greater real-world creative achievement (a self-reported measure of creative achievement) in college-age students with ADHD (who self-reported prior ADHD diagnosis and ratings of ADHD symptoms) than was reported by non-ADHD college peers (d = 0.90; White & Shah, 2011). Unfortunately, this self-report of creative achievement has not been validated. Also, using a self-report preference scale for problem identification, idea generation, solution development, and solution implementation, White and Shah (2011) reported a preference for idea generation in their ADHD group, whereas the non-ADHD group preferred solution development—findings similar to the results of a previous study with adolescents (Abraham et al., 2006).

In sum, we have evidence of creative performance for individuals with ADHD with average to above average IQ that was related to the generation of unique solutions (e.g., alternative uses and unique ideas, themes/plots, and strategies) and primarily during the performance of short duration tasks. These effects were documented more often with adults than children and more often when performance was brief or timed and there were few preexisting stimuli to hold in mind. Perhaps under these task conditions, the poor working memory documented for the ADHD population (e.g., Carson et al., 2003; Koffler, Rapport, Bolden, Sarver, & Raiker, 2010; Rhodes, Park, Seth, & Coghill, 2012) would not be expected to offset their creative abilities.

Group Comparisons of Assessed Creativity

The task attributes of creativity could be operationalized using normative assessments of divergent thinking, typically on tests such as the Torrance Tests of Creative Thinking, Figural Form A, using the Creativity Index (TTCT; Torrance, 1966, 2006). On this assessment, Cramond (1994a) reported that 32% of the 34 participants with ADHD (age 6-15 years) scored at or above the 90th percentile and 50% scored above the 70th percentile on the TTCT. Shaw and Brown (1991) identified two equivalent groups of high IQ, 11- to 12-year-old students with and without ADHD and reported that the students with ADHD attained higher scores on the Creativity Index of the TTCT Figural Form A than the students without ADHD. However, Healey and Rucklidge (2005) also examined 10- to 12-year-old students with equivalent but average IQ (ADHD, M = 110, and typically developing, M = 116) and reported no differences between groups on the Creativity Index, with only 9% of the ADHD group scoring higher than the 90th percentile on the TTCT. Thus, the 2005 study reported no evidence of creativity in an average IQ ADHD sample. When these researchers later compared creative and noncreative students, defined by Creativity Index scores above the 90th percentile on the TTCT, 40% of those creative students were at risk for ADHD; a rate that was 4 times higher than the 9% that would be expected within the general population (Healey & Rucklidge, 2006).

Summary

In psychology, creativity has been defined as the process of incorporating seemingly irrelevant and unrelated information to solve problems (Runco, 2004). This suggests that a wide focus of attention, often described as distractibility and documented for individuals with ADHD, may be useful for creative thought and insight. Prior findings reporting creativity in ADHD more than in non-ADHD groups (a) have annotated an overlap of social behavioral characteristics with students who are gifted; (b) have documented creative performance on divergent thinking tasks, such as telling more creative stories, using more nonverbal information and strategies during problem solving, generating more alternative and unusual uses of objects, and contributing to a higher percentage of correct problem solutions in cooperative groups; and (c) have been self-reported by adults with ADHD, as more creative achievements and as preferring generating ideas to clarifying ideas. The literature that failed to find differences in creativity between individuals with and without ADHD appears to have assessed untimed and extended task performance requiring synthesis of preexisting stimuli. However, Healey and Rucklidge (2005) also reported no significant differences in divergent thinking on the TTCT (the Creativity Index) between groups of students with equivalent but average IQ.

The purpose of the current study was to compare creativity, defined in this study as divergent thinking, and working memory in gifted students with characteristics of ADHD and in their gifted peers without ADHD characteristics. We selected a gifted population of students with ADHD characteristics, because an assessment of average IQ students failed to yield t-test group differences on the total TTCT Creativity Index or on a two-string problem task (Healey & Rucklidge, 2005). In other words, it may be the interaction of students’ high fluid intelligence and ADHD characteristics that provides the optimal environment for creativity or it may be that working memory is not compromised in students with high IQ. This study also provides an advance over prior clinical work through its assessment of creativity, working memory, and fluid intelligence within one school-based sample of gifted students rather than an examination of these variables in relative isolation.
We hypothesized that even though the working memory in twice-exceptional students might be lower than that of gifted students without these characteristics, creativity could be higher when it is operationalized as divergent thinking. More specifically, we operationalized creativity through its assessment on the TTCT using the Creativity Index, similar to Healey and Rucklidge (2005, 2006). For the purposes of this assessment of working memory and creativity, a one-way group comparison study was used to examine gifted students with and without characteristics of ADHD who had equivalent fluid intelligence. In addition to assessing group differences in working memory and creativity, we were interested in the interrelationships among the interval variables of ADHD, inattention, creativity, and working memory.

Method

Participant Recruitment and Selection Criteria

The sample included students from a summer residential camp for gifted, creative, and talented students held at a Midwestern university. An invitation to participate was e-mailed to the addresses provided on the camp application forms along with appropriate assent and consent forms to students in Grades 5 through 12, age 10 to 17 years, who had been accepted into the 2011 and 2012 summer residential camp programs. Our invitation stated that we would assess “working memory (the ability to maintain attention to information) and creativity (the ability to reorder elements in a new and useful way).” Sixty-eight students consented to the study and were screened for participation. All these students met the admission requirements of the summer residential program for gifted students, which included documentation of two of the following: (a) an IQ score of 120 or above, (b) a score in the 90th percentile or above on a national or state achievement or aptitude test, or (c) a grade point average (GPA) of 3.5 or greater in talent areas (e.g., mathematics, chemistry). Of this school-based sample, only 3% submitted IQ as a qualifying marker.

For this study, we identified two groups of gifted students, those with characteristics of ADHD and those without. Although a clinical diagnosis of ADHD requires the use and interpretation of multiple measures by a qualified diagnostician, rating scales for ADHD symptoms are valid and useful measures for differentiating children with ADHD from normal, age-matched, community controls (American Academy of Pediatrics, 2000). Thus, in this study all the participants were screened using the Conners–Wells’ Adolescent Self-Report Scale–Short Form (CASS-S, Conners, 1997a). The CASS-S is designed to measure the emotional, behavioral, academic, and social functions of children ages 6 to 18. This scale yields data with good reliability, with coefficient alphas ranging from .75 to .85 (Bloom & Heath, 2000), as well as, construct validity (.83; Conners, 1997b). A number of studies have used this self-report scale as an outcome measure or in an assessment of co-occurring disorders (e.g., Bloom & Heath, 2000; Mazefsky, Kao, & Oswald, 2011). To provide general support for the use of self-ratings with our sample of 10- to 17-year-old students, prior research has assessed 10- to 13-year-old students with characteristics of ADHD (Grskovic & Zentall, 2010). In that study, student self-ratings were valid concurrent indicators of hyperactivity and impulsivity with the independent ratings of their parents on similar items.

The CASS-S consists of four subscales: Hyperactivity, Inattentive-Passive, Conduct, and an ADHD Index, with the ADHD Index representing ADHD, combined type. Students with a CASS-S T-score of 60 or higher on the Inattentive-Passive and/or ADHD Index scales were assigned to the group of gifted students with characteristics of ADHD, which fell within the guidelines on the CASS-S for identifying students at-risk for ADHD. Those with scores below 50 on both the Inattentive-Passive and ADHD Index scales were assigned to the group of gifted students without characteristics of ADHD. To differentiate those with characteristics of ADHD from those without these characteristics, participants whose T-scores fell between 50 and 59, within one SD, were excluded from further assessment.

Seventeen gifted students identified with characteristics of ADHD (10 males, 7 females) and 20 gifted students identified without (13 males, 7 females) comprised the final sample for this study with 31 students excluded. The ethnic breakdown of the students included in the final sample was 89% White, 8% Hispanic, and 3% Asian. There was no significant group difference in age, $t(35) = 0.67, p = .51$, $d = 0.22$, or in Fluid Intelligence, $t(35) = −0.013, p = .99$, $d = 0.07$, although expected differences were found in Inattention, $t(35) = −8.96, p < .001, d = 2.85$, and on the ADHD Index $t(35) = −12.03, p < .001, d = 3.83$. Generally accepted guidelines for interpreting the strength of the Cohen’s $d$ effect-size are as follows: 0.2 indicates a small effect, 0.5 indicates a medium effect, and 0.8 indicates a large effect (Howell, 2010).

In order to address the possibility of selection bias related to those who volunteered for participation and those who did not, the authors compared these two groups on some information taken from applications on their GPA ($N = 50$) and their performance on national or state norm-referenced assessments of achievement or aptitude ($N = 40$). Prior to analysis, percentiles from the norm-referenced tests were converted to scores of normal curve equivalence. Results of these analyses yielded no significant differences between these two groups in GPA, $t(48) = 1.47, p = .15$, or in norm-referenced achievement test performance, $t(38) = 0.60, p = .55$.

Instruments

Creativity. The TTCT (Torrance, 1966, 2006) is a commonly used standardized, norm-referenced test of creativity (e.g., Cramond, 1994a; Healey & Rucklidge, 2005; Shaw &
Brown, 1991). It demonstrates good rater reliability (coefficient alpha centered at .89): “Coefficients at this level for a ‘projective’ instrument are highly satisfactory” (Torrance, 2008, p. 44). Criterion validity, the ability of the assessment to predict future creative production, has been documented, with TTCT scores positively related to current criteria of creative thinking (e.g., leadership activities, evaluation of drama talent, and teacher evaluation of student creative thinking activities; Chase, 1985). Cramond, Mathews-Morgan, Bandalos, and Zuo (2005) reviewed data from the 40-year follow-up study of students who had completed the TTCT in 1958 to determine the predictive validity of the assessment with the creative achievement those students actually attained in adulthood. They used structural equation modeling to examine these longitudinal data and found that the TTCT explained 23% of the variance in creative production (e.g., high school, post–high school, and living arrangement achievements, quality of future career image). The researchers cite the importance of this finding given the study length “and the fact that other important variables, such as motivation and opportunity mediate creative production” (Cramond et al., 2005, p. 289). Furthermore, Pearson product–movement correlations revealed IQ, flexibility, originality, and the Creativity Index to be the best predictors of the quality of creative achievement attained by the participants over the 40-year period.

Data collected from Figural Form A of the TTCT (the Creative Index) have been used to evaluate the creative potential of study participants (e.g., Healey & Rucklidge, 2005). The TTCT Creativity Index is derived from three subtests, which ask students to come up with novel drawings to include one of the following elements: an oval shape, incomplete figures, and two straight lines. Each of the three subtests is scored on five norm-referenced subscales—fluency, originality, elaboration, abstractness of titles, and resistance to premature closure—and 15 criterion-referenced measures, such as emotional expressiveness, movement or action, and synthesis of lines. According to Torrance (2008), these scores were not intended to provide individual assessments, but rather to be combined into one final Creativity Index to serve as the overall assessment of creative potential. According to the Technical Manual for the TTCT,

In the development of the streamlined versions of the TTCT, Figural Forms A and B, it was intended that the “creativity index” serve as the overall assessment. Results from the separate assessments—fluency, originality, elaboration, abstractness of titles, resistance to premature closure—were intended to be pooled in such a manner as to provide the creativity index, rather than to provide assessments for any diagnostic purpose. (Torrance, 2008, p. 45)

Working memory and fluid intelligence. The Woodcock Johnson III Normative Update Cognitive Abilities (Woodcock, McGrew, & Mather, 2001; Woodcock, McGrew, Mather, & Schrank, 2007) subtests that assess working memory and fluid reasoning were administered and are reported using T-scores generated by the scoring software provided by the test publisher. Internal consistency estimates for the Woodcock Johnson III Normative Update Cognitive Abilities are good (coefficient alpha ranges from .80 to .90 for individual tests; >.90 for cluster scores) with high interrater correlations on individual tests, r > .90 (Cizek, 2003). Specifically for this study, students were assessed using the Numbers Reversed (r = .86), Auditory Working Memory (r = .84), Concept Formation (r = .95), Analysis-Synthesis (r = .89), Number Series (r = .85), and Number Matrices (r = .91) subtests with coefficient alphas for the working memory and fluid intelligence cluster scores reported to be.90 and.95, respectively (McGrew, Schrank, & Woodcock, 2007).

Procedures

Participants were assessed in a private conference room over a period of 2 weeks when they were enrolled in the summer camp but not when participating in classes. During two 1-hour individual sessions a trained experimenter administered the WJ III COG NU to participants to assess working memory and fluid intelligence followed by a group administration of the TTCT. Demographic information taken from participant applications together with ratings and test results were entered into a database. All analyses were conducted using the SPSS 20 software package.

Results

Table 1 provides group means (M), standard deviations (SD), and effect sizes (d) of the descriptive statistics used in the group analysis. Descriptive statistics initially examined the assumptions of parametric statistics for the gifted and gifted with characteristics of ADHD groups for the dependent variables of working memory and creativity, defined in this study as the Creativity Index of the TTCT. Because of the large variances found in those scores, square root transformations were applied to the working memory and Creativity Index data, which follows from previous research that often documents greater performance variability for students with ADHD, especially when using limited sample sizes (Zentall, 2006). Subsequently, the Levene test yielded equivalent variance between groups for the square root–transformed Creativity Index, F(1, 35) = 1.215, p = .28, and the square root–transformed working memory scores, F(1, 35) = 0.015, p = .90. The main analyses were conducted on these square root–transformed scores using a multiple analysis of variance (ANOVA), which met the assumptions of more subjects per cell than dependent variables, and used the Wilk’s criterion that controlled for Type I error (Tabachnick & Fidell, 1996). This analysis yielded a significant main effect of group (gifted with and without characteristics of ADHD),
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F(1, 35) = 4.19, \( p = .024 \), \( \eta^2 = .19 \) (a large, partial eta-square effect size, Stevens, 2002), which provided justification for subsequent analyses of these dependent variables at the univariate level.

**Group Differences in Working Memory and Creativity**

An independent-samples \( t \) test was conducted to assess group differences on the transformed dependent variables of working memory and the Creativity Index. Yielded in this analysis were differences between the groups in working memory, which were significant, \( t(35) = 2.19, p < .05, d = 0.73 \), with a medium effect size. These findings indicated poorer working memory in the group of gifted students with ADHD characteristics, which were of practical/clinical significance using Cohen’s \( d \) effect sizes, between 0.5, a medium effect and, 0.8, a large effect (Howell, 2010).

Similar to the main Creativity Index analysis of Healey and Rucklidge (2005) but different in outcome, the main ANOVA findings indicated that gifted students with characteristics of ADHD had greater creative potential than those without ADHD, \( t(35) = 2.43, p < .05, d = 0.80 \). The large overall effect size on the TTCT Creativity Index indicated that these results were practically important, as well as statistically significant. Further analysis of group performance on the TTCT showed that 41% of this gifted group with ADHD characteristics scored at or above the 90th percentile on the Creativity Index score with a greater overall percentage of 53% scoring at or above the 70th percentile.

**Supplementary Analyses**

Although our original research question was related to creativity (i.e., conceptually defined as divergent thinking and operationalized as the Creative Index on the TTCT), Healey and Rucklidge (2005) also assessed the individual subscales that constitute the Creative Index. Thus, for comparative purposes, we subsequently conducted a one-tailed ANOVA of the individual subscales on the TTCT, with the justification that multiple ANOVAS are appropriate when some or all the outcome variables under current study have previously been studied in univariate contexts (Huberty & Morris, 1989). These analyses yielded significant group differences with medium effect sizes in Elaboration, \( t(35) = −1.85, p < .05, d = 0.61 \), and Abstractness of Titles, \( t(35) = −1.86, p < .05, d = 0.62 \) (see Table 1). Such findings may be useful in an interpretation of future replication studies or to provide comparisons with prior creativity research with average IQ students.

In addition, Pearson coefficients yielded significant correlations between the Creativity Index and each of the subscales. The subscales of Elaboration and Abstractness of Titles yielded the strongest associations with the total Creativity Index score. Specifically, the positive associations found were for Originality (\( r = .42, p < .05 \)), Elaboration (\( r = .60, p < .01 \)), Abstractness of Titles (\( r = .63, p < .01 \)), and Resistance to Closure (\( r = .60, p < .05 \))—with the exception of fluency, \( r = .32, p = .054 \).

More informative were the Pearson correlation coefficients among the interval variables (working memory, creativity, fluid intelligence, the ADHD Index, and Inattention).

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**Table 1. Descriptive Data for Gifted Students With ADHD and Without ADHD Characteristics.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>With ADHD characteristics</th>
<th></th>
<th>Without ADHD characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( M )</td>
<td>( SD )</td>
<td>( M )</td>
<td>( SD )</td>
</tr>
<tr>
<td>Age in years</td>
<td>14.11</td>
<td>1.46</td>
<td>14.44</td>
<td>1.53</td>
</tr>
<tr>
<td>Inattention</td>
<td>64.29</td>
<td>9.90</td>
<td>43.15</td>
<td>3.44</td>
</tr>
<tr>
<td>ADHD Index</td>
<td>64.77</td>
<td>8.83</td>
<td>39.55</td>
<td>2.95</td>
</tr>
<tr>
<td>Fluid Intelligence</td>
<td>528.88</td>
<td>6.59</td>
<td>529.45</td>
<td>9.24</td>
</tr>
<tr>
<td>Fluency</td>
<td>100.00</td>
<td>17.86</td>
<td>97.80</td>
<td>17.43</td>
</tr>
<tr>
<td>Originality</td>
<td>95.77</td>
<td>24.75</td>
<td>98.20</td>
<td>18.91</td>
</tr>
<tr>
<td>Elaboration</td>
<td>109.82</td>
<td>19.32</td>
<td>98.20</td>
<td>18.91</td>
</tr>
<tr>
<td>Abstractness of Titles</td>
<td>125.35</td>
<td>23.76</td>
<td>109.80</td>
<td>26.51</td>
</tr>
<tr>
<td>Resistance to Premature Closure</td>
<td>80.65</td>
<td>28.20</td>
<td>83.15</td>
<td>17.71</td>
</tr>
<tr>
<td>SQRT Creativity</td>
<td>11.04</td>
<td>0.74</td>
<td>10.48</td>
<td>0.64</td>
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<tr>
<td>SQRT Working Memory</td>
<td>7.29</td>
<td>0.62</td>
<td>7.78</td>
<td>0.72</td>
</tr>
</tbody>
</table>

Note. ADHD = attention deficit hyperactive disorder; SQRT = square root.

Fluid intelligence means and standard deviations for both groups in this sample were significantly higher than those of the test’s normative sample, gifted with ADHD characteristics, \( F(1, 795) = 14.36, p < .001, d = 1.14 \); gifted without ADHD characteristics, \( F(1, 798) = 18.12, p < .001, d = 1.11 \).

\( *p < .05 \), \( **p < .001 \).
Positive correlations were expected based on the literature review and found between working memory and fluid intelligence \((r = .60, p < .01)\) and between the ADHD Index and Inattentiveness subscale scores \((r = .89, p < .01)\). The authors also found significant negative correlations between working memory and ADHD Index \((r = -.37, p < .05)\) and between working memory and scores of Inattentiveness \((r = -.43, p < .01)\). Table 2 provides an overview of these results. In addition, a significant inverse relationship was documented between working memory and creativity, as measured by the Creativity Index \((r = -.34, p < .05)\). A visual examination of the individual data in Figure 1 shows this inverse relationship, with some students with giftedness and ADHD characteristics demonstrating poor working memory and yet high Creativity Index scores—seen in the top left corner of the scatter plot, and fewer with poor working memory associated with low Creativity Index scores shown in the lower right center.

**Discussion**

The purpose of this study was to determine whether gifted students with characteristics of ADHD would have higher assessed creativity than gifted students without these characteristics. This possibility was counterindicated by evidence of poorer working memory often documented in clinically diagnosed samples of students with ADHD. Working memory was important to assess with a sample of gifted students, because much of the clinical literature has examined children with ADHD and co-occurring disabilities, who often have lower IQ.

In the current study, even when assessing a gifted sample, we also found lower working memory for students with characteristics of ADHD with equivalent fluid intelligence to those gifted students without these characteristics. In addition, we reported a stronger association between working memory and fluid intelligence \((r = .60)\) than reported earlier as .21 to .53 with typical adults, assessed on the Berlin Intelligence Structure Model (Süß et al., 2002). We also reported that lower working memory was associated with higher scores on the ADHD Index and on the Inattentive subscale. These findings are consistent with previously reported associations for clinical groups of children between working memory and ADHD (Alderson, Rapport, Hudec, Sarver, & Kofler, 2010; \(r = -.85\)) and working memory and inattentiveness (Kofler et al., 2010; \(r = -.49\)).

It was important to examine working memory, because it was possible that poor working memory could interfere with the ability to hold information in mind, which could reduce the ability to make novel combinations of information (i.e., creativity). However, we reported a negative relationship between working memory and the Creativity Index across

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**Table 2.** Correlations Among Variables Assessed on WJ III NU COG, TTCT, and CASS-S.

<table>
<thead>
<tr>
<th>Variables</th>
<th>WM</th>
<th>Creativity</th>
<th>(g^F)</th>
<th>ADHD</th>
<th>Inattention</th>
</tr>
</thead>
<tbody>
<tr>
<td>WM*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativityb</td>
<td>−.34*a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g^F)</td>
<td>.60*a**</td>
<td>−.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHDd</td>
<td>−.37*a</td>
<td>.35*a</td>
<td>−.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentione</td>
<td>−.43*a**</td>
<td>.20</td>
<td>−.03</td>
<td>.89*a**</td>
<td></td>
</tr>
</tbody>
</table>

Note: ADHD = attention deficit hyperactive disorder; TTCT = Torrance Tests of Creative Thinking; WJ III NU COG = Woodcock Johnson III Normative Update Cognitive Abilities; CASS-S = Conners–Wells’ Adolescent Self-Report Scale—Short Form.

*aWM = Working Memory; cluster T-scores assessed using the subtests of Numbers Reversed and Auditory Working Memory of the WJ III NU COG. 
*bCreativity = Creativity Index score assessed by the TTCT. 
*c\(g^F\)= Fluid Intelligence; cluster T scores assessed using the Concept Formation and Analysis-Synthesis subtests of the WJ III NU COG indicate students’ ability for inductive (i.e., inferential) and deductive (i.e., general sequential) reasoning and rule application. 
*dADHD = ADHD Index scores assessed on the CASS-S indicate students who are “at risk” for ADHD the combined subtype. 
*eInattention = Scores assessed on the CASS-S indicate problems with organization, task completion, and concentration.

*p < .05. **p < .01.
both groups of students, which accounted for 12% of the variance; that is, the poorer the working memory the higher the creativity. This finding is different in direction (but of similar magnitude) to those findings reported for typical university students and staff members, whose creativity (timed tasks of verbal, figural, and numerical fluency) was compromised by poor working memory (Süß et al., 2002). Thus, in the current study with gifted students and in spite of their poorer working memory, we documented significantly greater creativity (divergent thinking assessed on a normative test) for the gifted students with ADHD characteristics than in their gifted peers without ADHD characteristics.

Furthermore, 53% of the gifted group with ADHD characteristics scored at or above the 70th percentile on the TTCT Creativity Index, which is comparable to findings reported by Cramond (1994a) of 50% above the 70th percentile on the TTCT (i.e., when assessing creativity in a sample of 34 students with ADHD and varying educational abilities). The only other work located that made group comparisons in creativity on the TTCT reported no differences between equivalent but average IQ groups of students and no differences from the normative test distribution (Healey & Rucklidge, 2005). In their 2006 study, these researchers also failed to find group differences on the Creativity Index. However, their ADHD group was clinically diagnosed and excluded students who scored at the 90th or higher percentile on the Creativity Index. Thus, in this 2006 study, their conclusion of no group difference in creativity was confounded by their participant selection/exclusion procedures.

**Theoretical Implications**

In this study, we did not find overall support for the threshold theory that the association between creativity and intelligence decreases at higher levels of intelligence. That is, creativity appears to be enhanced in gifted populations of students with ADHD characteristics. These conclusions are tempered by the fact that (a) creativity was assessed normatively as divergent thinking, (b) intelligence was assessed as fluid intelligence, and (c) both groups of students were assessed within a restricted range of intelligence, which was significantly higher than the test normative sample (see Table 1).

**Educational Implications**

This study has implications for the identification of twice-exceptional students and their educational programming. Specifically, divergent thinking and assessments of creativity could be used in the identification of giftedness within the ADHD population. If divergent thinking and creativity were compensatory strengths, these abilities could be used to improve educational programming for these students. Furthermore, assessments of creativity as an alternative measure of giftedness may identify more twice-exceptional students. For example, twice-exceptional students may respond better to tasks of fluid intelligence that emphasize nonsequential and divergent thinking rather than tasks requiring crystallized intelligence that emphasize recall of facts.

In the school setting, the challenge becomes how to create an environment in which creativity is emphasized as a pathway to learning as well as an outcome of learning. For example, problem-based learning allows students to engage in authentic learning experiences and may be especially appropriate for this twice-exceptional population (Dunlap, 2005). Subject area implications include creative writing and problem solving within science, social studies, literature, and mathematics. Furthermore, learning can be demonstrated using different products (e.g., in cartoons, role-play, enacting plays and fantasies, blogs, videos, newspaper articles) and in the revision of these products for different audiences. Some of these activities have been self-reported by students as young as Grade 2 and by their teachers (Zentall et al., 2001).

Although this study assessed the divergent thinking of gifted students with characteristics of ADHD, it is also possible that the educational implications could extend to students with ADHD without giftedness. The evidence presented earlier citing original stories and creative problem-solving performance, especially within challenging time-limited conditions and with stimulating games, supports the potential generality of educational implications to average IQ students.

**Limitations and Future Research**

There are several possible limitations to the current study. First our sample was small. The problem of small samples is the greater likelihood of failing to detect significant effects, known as Type II error (Levine & Hullett, 2002). That is, large sample studies that use reliable measures almost always produce an outcome of statistical significance (Harrison, Thompson, & Vannest, 2009). In this study, a relatively small sample of 37 students was comparable to prior studies in this area with sizes ranging from 32 to 93 participants (Abraham et al., 2006; Carson et al., 2003; Cramond, 1994a; Healey & Rucklidge, 2005, 2006; Shaw & Brown, 1991; White & Shah, 2006, 2011). Furthermore, the authors documented significant effects with large effect sizes for the reported differences between the groups, such that Type II errors are not likely to be a limitation of this study. These large effect sizes were reported to provide support for the educational importance of our statistical findings, independent of sample size.

However, there are limits to the generality of the results due to the assessments used. The camp population required that all students demonstrate giftedness, with the majority providing achievement and/or grades in a talent area; these students were then assessed for fluid intelligence and found to be significantly higher than the test normative group. However, alternative assessments of giftedness could extend the generality of our findings. Additional assessments of creativity could also extend generality by using laboratory tasks.
(e.g., alternative uses) and instructional tasks (e.g., alternative projects).

Limitations may also be because of the nature of participants selected from the gifted camp. Because these students were attending a residential camp for 2 weeks, we used self-ratings to identify ADHD characteristics, as the students were new to the teachers and to the camp setting. Furthermore, there may have been differences between those students who volunteered to participate and those who did not and were not assessed in this study (i.e., in addition to our documentation of equivalent age and grade average). It is also unknown whether students with characteristics of ADHD were taking medication at the time of the study. Results related to the effects of medication on the creativity of students with ADHD are inconclusive, with some researchers noting a decrease in the creative ability of students while taking ADHD medications (Swartwood, Swartwood, & Farrell, 2003), whereas others have found no effects (Funk, Chessare, Weaver, & Exley, 1993).

Overall, future research could extend generality to additional ADHD samples by assessing students (a) with teacher and parent ratings of ADHD assessed by a qualified diagnostician, (b) who are gifted but younger than the mean age of 14 years used in this study, (c) with average IQ scores from school-based samples, and (d) clinically diagnosed with ADHD, who often have lower IQ, co-occurring disabilities, and prescriptions for psychostimulant medication. The clinical diagnosis of ADHD involves multiple measures, including teacher and parent ratings, self-assessments, markers of academic or social impairment, and observations of the characteristics or symptoms of ADHD by qualified diagnosticians.

Perhaps more important, future research could advance our understanding of the creative performance of gifted students with ADHD through an examination of the types of creative tasks that might be compromised by poor sustained attention or working memory (i.e., tasks that involve sequential processing or extended attention to detailed information) and contrasted with those that do not involve working memory and hold greater promise for this population of twice-exceptional students. In addition, the components of creativity could be operationalized and assessed in future research (Sternberg, 1999).

Conclusion

We concluded that ADHD is associated with creativity when it is assessed by behavior and personality, but there is better evidence of creative performance on storytelling and problem-solving tasks (generating more unique ideas, strategies, solutions, and uses of objects) in average IQ groups of students with characteristics of ADHD than for comparison groups. From the data in this study, we further concluded that creativity, defined as divergent thinking assessed on the TTCT using the Creativity Index, is not compromised by poor working memory for a gifted group of students with characteristics of ADHD. In fact, there was correlational evidence that poor working memory was associated with improved divergent thinking.

Even though gifted students with ADHD often experience obstacles in school, evidence of greater potential for creative achievement exists. Indeed, the results of this study suggest that the combination of inattentiveness and hyperactivity contributes to creativity. This was documented in the positive correlation reported in this study between the ADHD Index and the Creativity Index, suggesting that inattention and hyperactivity combined may contribute to creativity more than inattention alone—the latter of which has been suggested by prior researchers (e.g., Carson et al., 2003). The implications of this study are related to the need for appropriate educational opportunities that capitalize on these strengths of this twice-exceptional population.

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References


**Author Biographies**

**C. Matthew Fugate** is a doctoral candidate in Gifted, Creative, and Talented Studies at Purdue University. Prior to attending Purdue, he received his bachelor’s degree in Interdisciplinary Studies from the University of Houston and master’s degree in Educational Psychology, Gifted Education from the University of Connecticut. In addition to his research on twice exceptionality, he is part of a team focused on increasing research, identification, and servicing of gifted Native American populations. He has served on several National Association for Gifted Children committees and has been Graduate Student Representative for the AERA Research on Gifted, Creative, and Talented SIG. He has presented to parents, teachers, and schools in Texas, Pennsylvania, Minnesota, Arizona, North Dakota, and South Dakota on topics such as creativity, twice exceptionality, underserved populations, and Total School Cluster Grouping.

**Sydney S. Zentall**, PhD, is a professor of Educational Studies at Purdue University. Her academic degrees are from the University of California at Berkeley and the University of Pittsburgh. She has published numerous scientific articles on ADHD that are related to the effects of stimulation added to social and academic tasks (i.e., the optimal stimulation theory). She is a past president of the Division for Research of the Council for Exceptional Children and has been inducted into the Hall of Fame by Children and Adults with ADD. Current books include a 2006 text, titled *ADHD and Education* and a 2013 text titled *Students With Mild Exceptionalities*.

**Marcia Gentry**, PhD, is the director of the Gifted Education Resource Institute and a professor of Educational Studies at Purdue University where she enjoys working with her doctoral students. Her research has focused on the use of cluster grouping, the application of gifted education pedagogy to improve teaching and learning, student perceptions school, and on nontraditional services and underserved populations. She is currently directing several research projects aimed toward discovering and developing talents among students from underrepresented populations. She frequently contributes to the literature, regularly participates in international, state, and regional venues concerning gifted child education and educational research, and she serves on the editorial review boards of several journals in her field. She is widely sought as a consultant and enjoys integrating her research with real-school applications that have positive effects on student learning and teacher practices.