ADAPTING A TOOL TO ASSESS VISUAL-SPATIAL CREATIVITY IN CHILDREN WITH AUTISM BY BUILDING ON THEIR STRENGTHS

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

Traditional creativity tests may underestimate the creativity of children with Autism Spectrum Disorder (ASD) because of the tests' constrained nature, such as having a time limit, being limited to paper and pencil, or taking the test in an over- or under-stimulating environment. The goal of the present research was to adapt the William's Creativity Assessment Packet (CAP) to use SketchUp™, a three-dimensional modeling (3D) program, as a new forum for creativity testing that focuses on visual-spatial creativity. The goal was to develop a more authentic measure of creativity in an environment that builds on the interests and visual-spatial talents of children with ASD. First, the CAP was revised to apply to three-dimensional SketchUp™ projects, and then the psychometric properties of the revised tool were examined. A random selection of 27 student SketchUp™ projects was assessed using the revised scale. Measurement dimensions included fluency, flexibility, originality, and elaboration. The validity of the new tool was examined by comparing the creativity scores of the 27 projects using the new assessment tool to the creativity scores given to the same projects by a team of SketchUp™ experts. Results showed that the scores were significantly correlated for three of the four dimensions of the new assessment tool. The tool also showed high interrater reliability among coders (M = .82) using intraclass correlation (ICC). Results suggest that this adapted assessment test could be a visual-spatial creativity measure for children with ASD, as well as a creativity measure used by employers to determine

real-world creativity capabilities in their future employees, particularly employees on the autism spectrum.

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INTRODUCTION AND LITERATURE REVIEW

A nation's willingness to embrace creative minds is directly related to that country's innovation and progressiveness. Creativity is recognized as a catalyst for personal growth and economic expansion (Florida, 2002; Shneiderman, Fischer, Czerwinski, Myers, & Resnick, 2005). In a 2010 study of more than 1,500 CEOs worldwide, creativity was deemed the number one quality of a successful corporation (IBM, 2010), but the world's most creative minds, such as Galileo, Einstein, and Edison, have rarely been supported let alone embraced by society. According to Sternberg's triarchic theory, society often has a narrow view of intelligence that excludes creativity. A key element of intelligence is adaptability, and successful adaptation requires a combination of components, one of which is creativity (Sternberg, 1996). Even more provoking is that many creative minds have succeeded despite the opposition of the very society that eventually benefited from their efforts (Ghiselin, 1952). Many creative thinkers do not excel in typical classrooms and workplaces, because they often lack the social skills to integrate naturally, have such absurd ideas that they become ostracized, or are over- or under-stimulated in the physical work environment. People in general, not just those with autism spectrum disorders (ASD), often do better creatively in environments where they feel safe to explore and self-express, and where they are familiar enough with the task before them but still sufficiently challenged (Armstrong, 2010; Webb et al., 2005). How much more innovative would a nation be if they opened their minds to a new and growing group of creative thinkers? If society as a whole could guide its efforts to more fully understand creativity, we might help creative minds produce new ideas and be prepared to confront an onslaught of future natural disasters and societal dilemmas. Some of our greatest inventors and historical figures, such as Galileo, Edison, and Einstein, are believed to have some form of high-functioning autism, or Asperger syndrome (Armstrong, 2010; Webb et al., 2005). It is important to examine visual-spatial creativity in those with high-functioning autism to better understand how to tap into their creative strengths and in turn use those strengths to benefit individuals on the spectrum as well as the whole of society. The first step in studying and understanding creativity in individuals on the autism spectrum is to have authentic creativity assessments. The goal of the present study was to adapt an existing creativity assessment to apply to 3D visual products and then to make a preliminary assessment of the validity and interrater reliability of the new assessment tool.

Across time, standardized creativity tests have played to the strengths of neurotypical individuals, usually consisting of a timed test requiring written or drawn answers to be completed individually in a fixed time frame (California Department of Education, 2004). The goal of the present study was to adapt an existing creativity assessment so that it would build on the visual-spatial creativity strengths of individuals with ASD. Creating this new assessment tool will allow children on the autism spectrum to be on a fair playing field in terms of being assessed for creativity and provide a tool for future researchers to shed light on creativity in children with autism.

Autism

The American Psychiatric Association's (APA) Diagnostic and Statistical Manual of Mental Disorders (2011) characterizes an autism spectrum disorder (ASD) by (1) impairments in social interaction, (2) impairments in communication, (3) restricted repetitive behaviors, and (4) delays or abnormal functioning prior to 3 years in social interactions, language, or symbolic or imaginative play. High-functioning autism is often referred to as Asperger syndrome (AS) (Gillberg, 1991; Wing, 1981, 1986), which is characterized by repetitive behaviors and abnormalities of social functions, although there is no delay in speech or cognition as is often seen in lower-functioning ASD (World Health Organization, 1993). Autism spectrum disorders are often referred to as pervasive developmental disorders (PDD). ASD includes autism, Asperger syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS), childhood disintegrative disorder, and Rett syndrome.

Diagnoses of ASD are on the rise. In the early 1990s about 6 in every 1,000 children in the United States were diagnosed with ASD, but in 2006 that number had increased to about 1 in every 110 children (Rice, 2006). Utah experienced a more than 40% increase in diagnoses of ASD from 1993 to 2007. By 2008, 1 in every 47 children was on the autism spectrum—1 in 32 boys and 1 in 85 girls (Centers for Disease Control and Prevention, 2012).

Given the increases in autism spectrum disorders, it is vital that we better understand the strengths of children on the autism spectrum to help them succeed and have the most productive lives possible. Spotlighting their strengths will also benefit society as these children become adults and have the opportunity to contribute to society.

As more and more families have children with ASD, we must seek to understand the ways these children process life experiences so that their needs are met, which is one motivation for the larger program within which this study occurred. One such need of all human beings is creativity. By being aware of the creative strengths of children with autism, specifically visual-spatial creativity, their day-to-day lives will be enriched and their future careers will be better tailored to their natural creative talents, also benefiting future employers and society as a whole. The present study focuses on adapting a creativity assessment tool as an initial step towards measuring creativity in individuals with ASD. This tool will build on the strengths of children with high-functioning autism.

Creativity

Creative thinking in children is important to study because it sets the foundation for creativity in adulthood. From a broad view of the research, creativity is connected to social-emotional characteristics, divergent thinking—the ability to generate unique ideas that are useful—and healthy self-expression. Through creative development we find our niche and thrive, building self-confidence and discovering our purpose in the world.

According to Wright and Diener (2012), not as much research has been done on creativity in children than in adults, because it is more difficult to measure creativity in young children; since children have yet to produce anything of creative value to society, creativity at this developmental stage is usually measured through creative-thinking ability. Gilford (1950) was one of the first to establish fluency, flexibility, and originality as fundamental aspects of divergent-thinking creativity (Runco & Charles, 1993). Research on creative thinking in children has primarily focused on divergent thinking, which includes ideational fluency (number of responses) and originality (uniqueness of responses) (Wright & Diener, 2012). In this study I am using Sousa's (2009) definition of creativity, which includes four dimensions of creativity:

1. Fluency: the "ability to generate new ideas," to problem solve, and to create ideas for speaking, writing, and drawing diagrams or models. "In what ways can we do this?"
2. Flexibility: the ability to "generat[e] a broad range of ideas."
3. Originality: the ability to generate "unusual or unique responses to a situation."
4. Elaboration: the ability to add other ideas and details to current reasoning.

The Torrance Tests of Creative Thinking (TTCT) (1974) provides a variety of activities that allow children to display creative thinking through these four avenues of creativity. In the "Thinking Creatively in Action and Movement" test by Torrance, some of the activities include asking children (1) to demonstrate as many ways to move between two pieces of tape as they can, (2) to act like a tree in the wind or pretend like they are pushing an elephant off their favorite toy, and (3) to put a paper cup in the wastebasket as many ways as they can.

The ideas generated by the children are then scored for fluency, flexibility, originality, and elaboration. Children score higher on *fluency* than others if they more readily come up with ideas—the more ideas a child generates, the higher the fluency score. Children show less *flexibility* than others if in all of the ways they walk or run to the wastebasket, they involve only their feet, compared to other children who incorporate their hands, head, shoulders, and facial expressions. One child may display *originality* because he pretends to be walking to the wastebasket like he is on the moon and no other child thought of that. Another child may excel in *elaboration* because he generates multiple ideas based on his first idea to stomp to the wastebasket—then (1) stomping with flailing arms, next (2) stomping with flailing arms and grunting noises, and finally (3) stomping with flailing arms, grunting noise, and a karate chop on the trashcan.

Creativity is most prevalent when optimal arousal is achieved. According to optimal arousal theory, all human beings seek optimal arousal; it contributes to human development, and it is helpful in "negotiating a person-environment fit that is effective and rewarding" (Rathunde & Csiksentmihalyi, 2006, 469). Human beings tend to swing from being anxious to the extreme opposite of being bored and seeking distraction (Rathunde & Csiksentmihalyi, 2006, 469). Many children on the high-functioning end of the autism spectrum find typical classrooms either under or over stimulating (Schaaf & Miller, 2005; Tubbs, 2008), thus these children rarely reach optimal arousal or flow, or the "axis of this arousal continuum" (Rathunde & Csiksentmihalyi, 2006, 469). Flow experiences most often happen when a person's skills are being sufficiently challenged, where one feels in control while still being faced with new circumstances. This best occurs when in a safe, secure environment.

Autism and Creativity

Although creativity is important, few researchers have examined the relationship between autism spectrum disorder (ASD) and children's creativity. Key characteristics of Asperger's include intense focus on one topic, extraordinary persistence and observation, and high levels of energy and motivation (Fitzgerald, 2004). These characteristics along with others, such as ability to disregard social conventions, potentially link autism to creativity and innovative thinking (Gillberg, 2002). However, according to the APA (2011) definition of autism, some children with ASD lack varied, spontaneous make-believe play, have a fixation on restricted patterns of interest, and adhere to particular nonfunctional routines or rituals. Since flexibility is a key component of creativity, and children's make-believe play fosters adult creativity, children on the autism spectrum are often labeled as being less creative.

In fact, research has shown that children on the autism spectrum are less creative than neurotypical children, because children with ASD produce less-varied and more reality-based responses (Frith, 1972; Lewis & Boucher, 1991), and are more limited in their range of ideas (Craig & Baron-Cohen, 1999). One study analyzed color and tone sequences produced by children with autism, children with mental disabilities, and typically developing children (Frith, 1972). Children with autism ranged in age from 5 to 17 years, with 5 girls and 15 boys, and were divided into low mental age and high mental age (MA) using the Raven pretest. Half of the children with autism scored less than a 5-year-old MA, and the other half scored greater than an 8-year-old MA. Twenty typically developing children were controls, selected based on age to match the Raven MA scores. Ten severely mentally disabled children were also selected as controls to represent a low Raven MA score. These three groups of children were asked to produce eight color sequences using rubber stamps and various colors of inkpads, and two tone sequences using a xylophone, which were then scored numerically for complexity, rule adherence, restriction, and originality. A sequence was labeled original if it occurred only once or twice among all the trials. A correlation was found between intelligence and complexity scores for children with autism and typically developing children, thus showing that the higher the MA score, the more complex the sequences produced. Children with autism and a low MA were extremely adherent to the rules compared to typically developing children with a low MA, and were equally adherent as participants with a high MA. Compared to the controls, all participants with autism restricted themselves more from using the available tools (i.e., inkpads and rubber stamps), as well as displayed less originality in the sequences they created. These findings support the notion that children with autism are more rigid in following rules, often restricting their creativity. It can also be noted that this standardized creativity test did not play to the visual-spatial and technology-based strengths of many children with autism. The children were asked to create musical and color sequences on demand, which may not have sparked their creativity.

Although Frith found that children with ASD possessed less originality, a more recent study found the opposite. In this study the creativity of typically developing (TD) children was compared to the creativity of children with ASD (Roskos-Ewoldsen, Klinger, Klinger, Moncrief, & Klein, 2008). Using the Torrance Tests of Creative Thinking, the researchers scored the children, who ranged in age from 5 to 16, on fluency, originality, and flexibility for (1) generation and (2) exploration. Generation consisted of the children combining 3D shapes in useful ways, and exploration entailed the children telling an instructor how many different things could be done with a foam shape. The two groups showed no difference in flexibility, generation, exploration, and how often they created real objects, but children with ASD showed more unique designs (originality) than the TD group. Compared to Frith's research, this creativity measure utilized 3D shapes rather than music and colors, possibly tapping into the visual-spatial creativity of the children with ASD. There could also be complicating factors such as variations in diagnoses (i.e., low-functioning versus high-functioning autism) and IQs, as well as in time frames of when the studies were conducted.

Another study questioned whether children with Asperger syndrome (AS) are creative in divergent thinking and divergent feeling (Liu, Shih, & Ma, 2011). To evaluate creativity, 16 children (ages 10–11 years) with AS and 42 typically developing children were recruited from the same schools. These children completed the Creativity Assessment Packet (CAP) (Williams, 1980). The CAP included two assessments: (1) a divergent-thinking activity and (2) a divergent-feeling activity. The divergent-thinking activity gave the children 12 incomplete drawings and asked them to complete the drawings in a unique way and to also title each drawing. The drawings were scored on elaboration, originality, flexibility, openness, and fluency, and the titles were scored on humor, creativity, length, and complexity. The divergent-feeling activity was a self-rated creativity questionnaire scored on risk-taking, complexity, curiosity, and imagination. A sample question was: "If the final page of a storybook is missing, I will make up the story's ending myself." Answers consisted of "agree," "partially agree," and "disagree." To investigate the relationship between nonverbal creativity and nonverbal IQ and vocabulary size, the participants took the Test of Nonverbal Intelligence, Third Edition (TONI-3) and the Peabody Picture Vocabulary Test-Revised (PPVT-R). These tests are nonverbal, so the participants can nod or point to respond to each question. The drawings were scored by two raters who were blind to group status and who were certified special education teachers trained in CAP administration. Children with AS scored significantly higher than those of the control group in originality and elaboration. In openness and flexibility the children with AS scored much lower than the typically developing group.

Given that children with AS often have a unique interest that they are knowledgeable and passionate about, many of the originality scores were based on these particular interests. On the flip side of this strength, their intense interests may also hinder them from being flexible and open to new venues or interest. The CAP assessment packet may adequately measure some children's creativity, but many children on the autism spectrum could benefit from a visual-spatial creativity measure that utilizes computer technology, often one of their areas of interest, and an assessment that does not require fine motor skills, such as writing.

Purpose of This Study

The purpose of this research was to develop a new creativity assessment tool and examine some of its psychometric properties. Specifically, the goal of the present study was to adapt the Creativity Assessment Packet (CAP) to assess the visual-spatial creativity of children with high-functioning autism spectrum disorder (ASD). The hope is that the new assessment tool may ultimately be used to assess creativity in a way that is reflective of creativity in a real-world setting. One flaw of divergent-thinking creativity tests is that they often do not accurately predict future creative accomplishments in real-world settings (Zeng, Proctor, & Salvendy, 2011; Kaufman & Baer, 2012). To examine this real-world element in the adapted creativity tool, SketchUp™ experts participated in assessing creativity. SketchUp™ is a 3D-modeling software program that was used in the iSTAR workshops to allow the participants to create 3D models. The iSTAR workshops were created by a University of Utah interdisciplinary research team to teach children on the autism spectrum how to use SketchUp™ to create computerized 3D models.

Families were recruited from an email list from the original SketchUp™ seminar for the local community, and then parents were notified about a summer SketchUp™ workshop starting at the University of Utah. These workshops were advertised as being for children with high-functioning autism, ranging in ages from 6 to 18. The participants who chose to enroll in the workshop were white, male children between the ages of 7 and 17 years. Workshops also occurred at a local charter elementary school where the participants were teacher-selected, full inclusion, and neurologically diverse.

Another purpose of this research was to create an assessment tool that would play to the strengths and needs of children with high-functioning autism. To meet this goal, the adapted tool assessed projects that were created (1) using SketchUp™ (2) in a natural environment, (3) without time restrictions, and (4) without the children knowing that the projects would be assessed for creativity, thus reducing testing anxiety and allowing the SketchUp™ projects to be made naturally and spontaneously. Individuals with ASD often excel at computer tasks and additionally have excellent visual-spatial skills (Caron, Mottron, Rainville, & Chouinard, 2003; Mottron & Belleville, 1993), so it would be beneficial to adapt a scale to authentically measure visual-spatial creativity of children on the autism spectrum. By accurately measuring their creativity we could then better match these children to appropriate school curriculum and career paths, improving not only their life satisfaction but the whole of society.

The goal of this research was to adapt and evaluate an assessment of creativity to be used with children with ASD in a more natural environment in a way that plays to their strengths. Traditional creativity tests ask participants to be creative on demand in a way that does not tap into their visual-spatial creativity through technology, so it is not surprising that many if not most of the research findings show that children with ASD are less creative than typically developing children. My hope is that this research can provide an assessment tool to measure creativity in children with ASD that is replicable, can be easily used by future researchers in conjunction with other tools, and more accurately reflects the visual-spatial creativity in these bright children.

METHODS

Participants

Of the15 boys who participated in the iStar workshops, 9 of them were included in this study—8 of the boys were from the iStar after-school program at the University of Utah and 1 of the boys was from the charter school iStar workshops. These children were all enrolled in the SketchUp™ workshops for at least 2 consecutive semesters (approximately 10 workshops over a period of 6 to 8 months). Only the children who had completed 3 or more projects during the workshops were included in the sample, thus ensuring that the projects came from participants who were engaged in SketchUp™ during the workshops.

All of the children except for two came from middle-class families in which both parents had college degrees, and most families had two children. Parents reported that 6 of the 9 participants had a diagnosis of autism, more specifically high-functioning autism or Asperger syndrome (AS). The participating boys also had diagnoses that included developmental delays, attention deficit, and disruptive behavior disorders. Eight of the boys were enrolled in inclusive classrooms at their schools, and one was in a learning disorder (LD) classroom.

Procedure

Adapting the Creativity Assessment Packet (CAP)

The first step of the research was to adapt the Creativity Assessment Packet (CAP) for use with a 3D project created using Google's 3D-modeling program SketchUp™. The original CAP assessment was designed for paper and pencil drawings created on demand for the assessment. The present study adapted the coding scheme of the CAP for each of the four dimensions of creativity—fluency, flexibility, originality, and elaboration. Two researchers discussed each dimension and coding scale and pilot tested the revised assessment on 3D projects and revised the coding scheme multiple times until it consistently applied to the 3D projects.

Next, the interrater reliability of the new assessment was examined. Three projects from each of the 9 participants were randomly selected, totaling 27 projects. Then, 5 female coders—4 of whom were graduate students and 1 of whom was an undergraduate student at the University of Utah—were trained to code the SketchUp™ projects using the new measure. These women had varying technology experience, and none of them had used SketchUp™ before joining this research project. Under the supervision of faculty research team members, the 5 coders came together 4 different days to be trained in the basics of SketchUp™ and coding. In the first training session we taught the coders how to use SketchUp™'s basic tools and how to code the projects using the measure. Next, coders coded projects independently so that interrater reliability could be assessed on their independent codes. The following three meetings we assessed interrater reliability by comparing the scores each coder had given designated projects using the adapted measure and reached consensus on disagreements. Faculty team members were in attendance during each of the meetings to give input and suggestions. Initially, each coder assessed the same 7 projects during this time to assess interrater reliability.

Then the same coders each scored 6 projects independently, with some overlap of projects. Of the total 27 projects, 7 projects were coded by all five coders; 8 projects were each coded by a single coder; and 11 projects were each coded by two coders. Each coder did their coding from a personal computer after downloading the SketchUp™ software. Once the assessments were collected, the scores of the 11 projects that were coded by two coders were compared, and discrepancies were resolved via discussion. On average it took a coder approximately 20 minutes to code a project.

Measures

Adapted Measure's Assessments of Creativity

The measure of creativity that we implemented assesses creativity using SketchUp™, a 3D-modeling computer program, while still measuring flexibility, fluency, originality, and elaboration. Although the framework of measuring these four dimensions of creativity parallels the CAP, there were some significant changes made to adapt the measure to meet the needs of children on the autism spectrum. Scores were weighted since the maximum and minimum scores in each of the four dimensions varied.

Fluency

Fluency is the ability to generate a large number of ideas. The first section of the CAP scores fluency based on how many of the twelve given boxes are filled with participants' drawings. In SketchUp™ there is, in essence, one large area in which to create rather than 12 smaller places, so the adapted measure assessed the number of components in the project—components being downloaded objects and self-made objects—to demonstrate the participants' ability to generate a large number of ideas. The SketchUp™ 3D-modeling program automatically counts all components downloaded from the warehouse into a project, and the self-made objects are counted manually. The maximum points available in this section was 20, for ease of the coder counting the self-made objects, representing a total of both self-made and downloaded components. The mean fluency score was 10.11, *SD* = 6.99, range = 1–20.

Flexibility

The next section of the CAP is flexibility. To score flexibility according to the CAP, one must identify items drawn in the 12 boxes that fall into the categories *Living, Mechanical, Symbol, View,* and *Utility* to show a broad a range of ideas. The CAP scores this category based on the "number of times the picture shifts from *category of first frame* across the five possible categories" (Williams, 1980). To accommodate SketchUp™, which does not have 12 frames, we identified the number of different categories (e.g., Living, Mechanical, Symbol, View, Utility, and Elements of Nature) included in each SketchUp™ project. The sum of the number of categories provided the flexibility rating. The CAP provides a list of example items that fall into these five categories, to which we added appliances, toilet, aquarium, and animated characters such as Pokémon and Transformers to fit the needs of the participants' projects. We also added a sixth category called *Elements of Nature*, which includes water, fire, earth, and wind, such as a puddle or flames. The maximum number of points possible in this section was 6, 1 point for each of the six categories. The mean for the adapted measure's flexibility score was 3.37, *SD* = 1.42, range = 1–6.

Originality

In the originality section of the CAP, the raters give points based on the participants adding to an existing image, getting 1 point for drawing outside the closure only, 2 points for drawing inside the closure only, and 3 points for drawing both inside and outside the closure. In our SketchUp™ workshops we did not give the children a partially made project to add to, so we assessed based on (1) how unique the project's theme was in comparison to the rest of the projects in the sample, and (2) how downloaded and self-made objects were combined in nontypical ways, giving the child a score for each of these two areas of originality. The originality of the theme of each project was evaluated in comparison to the other projects in the sample, so if the majority of the projects were about dinosaurs, those projects would be rated less original than a project that was the only one about extinct animals or being awesome. Because one dimension of originality was the uniqueness of the theme of the project, a list of the four most common themes was identified and included in the measure's instructions (e.g., dinosaurs, Halo/battle, Avatar, and Pokémon). There were 5 points possible for the originality of theme. The score for the combination of components was determined based on how uniquely the components and self-made objects were combined, so, for example, a child could combine a man and a pizza—two separate components—and that would be considered typical to everyday life, or a child could combine certain Pokémon characters in a way that is typical to a Pokémon world. Both cases were given 0 points. However, if a child combined a man with a pizza in a way that the man was smaller than the pizza and placed inside the pizza, that would be considered unique and received 1 point. One point was given for every unique combination of objects, with 5 points possible for having five or more instances of objects being used in nontypical ways; and, again, the maximum score for the uniqueness of theme is 5 points. Together these two scores—(1) Uniqueness of Project Theme and (2) Combination of Components—allow a maximum total originality score of 10. The mean for the adapted measure's originality score was 3.89, *SD* = 2.35, range = 1–9.

Elaboration and Titles

In the CAP the last two sections are elaboration and titles, but in the adapted measure we chose to combine them into one elaboration section. The creation of scene titles is a way to elaborate on the SketchUp™ projects, so the titles section easily merged into elaboration. Within the elaboration section of the adapted measure three areas are scored—(1) Scene Angles, (2) Altered Components, and (3) Scene Titles.

Although the CAP's concept of elaboration in creativity is similar to that of the adapted measure, there are striking differences as to how creative elaboration is measured on paper versus on a computer screen. The elaboration section of the CAP scores participants' drawings based on where details are added within the 12 boxes. Each box already has a line or shape printed in it. Children are given more points the more asymmetrical they make their drawing, elaborating on the existing shape. To utilize SketchUp™'s digital format and 3D warehouse, we adapted the CAP to score participants' projects based on how they used scene angles to elaborate on the storyline. Participants received more points the more intricate the scene angles, if the scenes moved the story forward, or if the scenes showed the audience more than they might see on their own. Zero points were given if there were no scenes, 1 point was given for basic movements of scene angles, and 2 points were given for unique movements of scene angles.

In addition to scoring scene angles, the elaboration section also scores any alterations the children made to components downloaded from the Google 3D warehouse. In the Altered Components area of elaboration we gave 1 point for a component being shrunk, enlarged, or upside down, etc., and 2 points for a component being altered by some part of it being taken away or by something being added to it. Three points were given when the component was altered in two ways at the same time, such as shrunk or added to. The maximum number of components that can be scored is 12 for ease of the coder, so with each component receiving a possible 3 points, the maximum for this section is 36 points.

The final section of the CAP scores the title the children give each of their 12 creations. A participant receives 0 points for not having a title, 1 point for having a simple title without a modifier (i.e., "The Elephant"), 2 points for having a name with a modifier (i.e., "The Flying Elephant"), and 3 points for having an imaginative name that expresses something beyond what is in the drawing (i.e., "So Long Sucker"). In SketchUp™ there is an option to title each scene created, so we implemented this portion of the CAP with the same point scale for scene titles. In the SketchUp™ workshops, the participants are not required or told to name their scenes, but we have found that many of the children do so anyway. We decided to combine the title section of the CAP with the elaboration section, since the creation of scene titles is a way to elaborate on the SketchUp™ projects. By so doing, the elaboration dimension of the adapted measure has

3 scores—(1) Scene Angles, (2) Altered Components, and (3) Scene Titles. The maximum points available for Scene Angles is 2, for Altered Components is 36, and for Scene Titles is 3, each score being weighted for the total elaboration score. Thus, the maximum number of points available in the entire elaboration section is 38. The mean for the adapted measure's elaboration score was 6.02, *SD* = 6.12, range = 0–30.

As a result, the new assessment tool is made up of four scoring areas—(1) fluency, (2) flexibility, (3) originality, and (4) elaboration.

Google's Assessments of Creativity

Because one goal was to examine the validity of the new assessment tool in terms of real-world creativity, we compared the scores on the new assessment tool to real-world ratings of the creativity of the project. A group of five Google SketchUp™ experts assessed the same projects according to the same four categories of creativity—fluency, flexibility, originality, and elaboration. The team members were given the definitions of these four words as well as instructions to rate each project on a scale of 1 to 5 for each of the four dimensions of creativity. As a team they assessed each project, analyzing each project together, discussing reasons for giving a certain score to each project, and coming to a consensus on all the scores.

Fluency

The Google team identified fluency as the ability to generate a large number of ideas as "themes" or "subjects" in a SketchUp™ project. For example, a project "containing several groupings of food items really only had one theme, food, and received a lower score" than "a model containing a water park complete with rides, game booths, and food stands" (Google, personal communication, 2012). The mean for Google's fluency score was 2.89, *SD* = 1.09, range = 1–5.

Flexibility

The Google team evaluated the projects for flexibility, or the ability to generate a broad range of ideas. As the team assessed each project they rated the models on a scale of 1 to 5, based on how many of the components and self-made objects fell under the same theme or idea. If a project had a lot of army men, guns, shooters, people being shot, etc., it got scored lower than a project that displayed more diverse items and ideas, such as a project with an ogre, a birdcage, a dragon, and roofless buildings. The mean for Google's flexibility score was 2.85, *SD* = 1.20, range = 1–5.

Originality

For scoring originality the Google team identified the uniqueness of a project's theme. The Google team rated the projects on a scale of 1 to 5 based on how original the theme was in comparison to the themes of the other projects in the sample. After reviewing the 27 projects, Google noticed that there were a lot of Halo themes and dinosaur-centered projects, so the models that "veered off the beaten path did well," (Google, personal communication, 2012). The mean for Google's originality score was 3.67, *SD* = 1.24, range = 1–5.

Elaboration

Finally, the Google team scored the projects on a scale of 1 to 5 for elaboration, or the ability to add other ideas or details to what already exists. The higher scoring projects were those in which the creator added new elements to a downloaded component and used scenes to “aid in a viewer’s understanding of the model” (Google, personal communication, 2012). For example, high-scoring projects added self-made lava to a downloaded volcano or used scenes to take the viewer on a simulated roller coaster ride. The mean for Google’s elaboration score was 2.94, *SD* = 1.50, range = 1–5.

RESULTS

Reliability

Interrater reliability was assessed using intraclass correlation (ICC). Intraclass correlation was chosen because it is appropriate when there are multiple coders coding multiple projects, as opposed to simple correlations or percentage agreement or kappas, which are all appropriate for 2 coders. There are several types of intraclass correlations. Intraclass correlation is derived from an analysis of variance model (Fagot, 1991; Shrout & Fleiss, 1979). According to Shrout & Fleiss (1979), three issues need to be examined in order to determine which type of intraclass correlation to use. First, one needs to determine whether the appropriate statistical model is a one-way or two-way analysis of variance. In a one-way analysis of variance approach, each target is rated by a different random sample of judges. In a two-way analysis of variance approach, each target is rated by the same judges. In the present study, all targets for interrater reliability were rated by the same set of five judges; thus, the present study used the two-way analysis of variance approach. The second choice is whether the effects of the raters are considered fixed or random. In the case of the present study, we cannot assume that the entire population of potential raters would have rated the projects the same. Thus, the effects were considered random, rather than fixed. Third, because we want to be able to come to consensus on a single rating among the coders, rather than 1 averaged score across multiple raters, the unit of analysis was a single rating, rather than the mean rating. In the present study, a random sample of five judges was selected from a larger population, and each judge rated 7 projects. This approach is the second case that Shrout and Fleiss describe, and it corresponds to a two-way Anova with random judge effects and a consistent set of raters. Thus, we used ICC(2) with absolute agreement on a single measure.

Table 1 displays the intraclass correlations for the four scales—fluency, flexibility, originality, and elaboration. Intraclass correlations with absolute agreement as a single measure ranged from .68 to .96 across the four scales of fluency, flexibility, originality, and elaboration, $M = .82$. Coders showed adequate to excellent consistency with one another, thus demonstrating good interrater reliability.

Validity

In order to assess the validity of the new assessment tool with real world ratings of creativity, the Google team's scores for each scale were correlated with the researchers' scores on the new assessment tool (see Table 2). As can be seen in Table 2, four out of the five correlations between the Google team's ratings and the ratings on the new assessment tool were significantly correlated. For example, Table 2 indicates that Google's total creativity score correlated significantly with scores from the new assessment tool, $r(27) = .71$, $p < .001$, indicating content validity in relation to Google SketchUp™ experts' construct of creativity.

Table 1

Reliability Among Coders Using Intraclass Correlation with Absolute Agreement

Scale	Intraclass Correlation as a Single Measure
Fluency	.96
Flexibility	.76
Originality	.78
Elaboration	.68

Table 2

Correlations between Ratings by Google Team and Ratings by Researchers for Dimensions of Creativity

Researcher	Google				
	Fluency	Flexibility	Originality	Elaboration	Total
Fluency	**.62****	.60**	.38	.61**	.65**
Flexibility	.48**	**.71****	.51**	.67**	.70**
Originality	.26	.41*	**.32**	.19	.32
Elaboration	.22	.33	.03	**.61****	.41*
Total	.52**	.71**	.40*	.74**	**.71****

*$p < .05$ **$p \leq .01$, two-tailed.
$N = 27$

DISCUSSION

Divergent-thinking creativity tests are often criticized for not predicting future creative accomplishments in real-world settings (Zeng, Proctor, & Salvendy, 2011; Kaufman & Baer, 2012). One of the objectives of this study was to compare scores on an adapted creativity assessment to creativity scores provided by real-world SketchUp™ experts working in a creative field professionally. The purpose was to evaluate how a score from an adapted creativity tool would compare to scores from those in a real-world career setting. Because the new tool is used in natural settings with few constraints on the participants, and because it correlated with the expert ratings of creativity, this new assessment tool may have greater potential for predictive validity than less authentic creativity measures.

Another objective of this research project was to adapt an existing creativity assessment tool to build on the strengths of children with high-functioning autism and to avert some of the problems with traditional creativity assessments when they are applied to children with ASD. We wanted to develop a creativity assessment tool that would offer children with ASD an equal playing field compared to neurotypical children. The strengths of this creativity test are that it (1) utilizes 3D-modeling computer software and (2) takes place in a natural environment. Many children on the autism spectrum excel at using computer software programs, especially 3D-modeling programs like SketchUp™, but the majority of standardized creativity tests utilize fine motor skills through drawing pictures, or verbal skills, which are often a challenge for children with autism. This new assessment also allows creativity to be evaluated in a natural learning environment without a time limit or rules against talking with others. These parameters are closer to the conditions in which real-world creativity occurs, which is typically collaborative and ongoing (Zeng et al. , 2011). In the iSTAR workshop environment, the children create whatever they want using SketchUp™, and this freedom to create is encouraged by their friends and instructors and enhanced by their growing self-confidence (Wright et al., 2011). The children are not told that their work is going to be evaluated but are told to create whatever they want because the possibilities in SketchUp™ are endless. Although we evaluated SketchUp™ projects made in iStar workshops, any natural learning environment could be conducive to creativity if, children are free to create without typical standardized test constraints, thus providing conditions that promote real-world creativity. For example, SketchUp™ could be used as part of a school curriculum, rather than in after-school workshops.

In terms of the psychometric qualities of interrater reliability and validity, the new assessment tool looks promising. There was moderate to high intraclass correlation among multiple coders, indicating that the assessment was scored reliably between raters. The tool proved to not only be reliable but also easy to use and time efficient for those assessing the projects, which offers logistical support in the real-world use of this measure. The University of Utah coders who scored the projects had never used SketchUp™ before but yet were able quickly learn the program as well as how to code after only one brief training meeting. Google experts' total creativity scores correlated significantly with the total creativity scores from the new assessment tool, indicating content validity in relation to the SketchUp™ experts' construct of creativity. This is important because, although the SketchUp™ experts are not the experts on creativity, they are representative of a group highly skilled in using SketchUp™, giving the new assessment tool more leverage in the real-world creative setting.

A possible limitation of this assessment tool is that the SketchUp™ experts' and the assessment tool's originality scores did not correlate. The SketchUp™ experts reviewed all 27 projects at once for theme originality, whereas University coders each saw only the projects they had coded, 13 projects each, which possibly limited the coders' ability to score projects in comparison to the entire sample. Coders of the new assessment tool were told the top four most popular project themes, but in the future all of the coders should see every project to know the range of themes. This might enable more valid coding of the originality of theme. Future research could evaluate how creativity scores compare when assessed by coders who have viewed each project before scoring the originality of theme portion of the tool compared to those who see only the projects they code. In addition to this, conceptually, Google did not score for originality based on the unique combinations of components as done by coders using the new assessment tool. Future research could evaluate the need for the Combination of Components section when scoring originality or determine how to improve the construct of originality to better hone in on traits of real-world creativity in this particular dimension.

In addition to the originality scores not correlating, there were some other limitations to the study. We pulled from a convenience sample that was small and narrow. All participants were male and came from Caucasian middle-class families, which was not representative of a broader population. Although there were around 100 projects available for assessment, our original research plan was to explore creativity in the children in our sample rather than adapt an assessment tool. For this reason we limited our sample to an equal number of projects to assess per child, so to assess as many children as possible, we included children who had completed at least 3 projects.

Due to the nature of the project, the new assessment tool was not compared to an existing creativity tool for validity. The SketchUp™ experts were used as the comparison instead of an existing creativity test because children with autism often do not perform to the best of their ability when being assessed by a standardized creativity test. Using an existing creativity test as a comparison was not the focus of this study, but this research does provide opportunities for future research in comparing this adapted measure to other standardized creativity tests. This type of comparison would strengthen the validity of the new assessment tool.

One strength of this study is the close collaboration we had with SketchUp™ experts. They offered a vital perspective on the creativity of the sample projects, considering their SketchUp™ background. This provided a valid comparison for the creativity tool for phase one of this project. Of the vast criticisms directed at standardized creativity tests, one of the main downfalls is that typical tests do not predict creativity in a real-world setting. So in essence, the existing creativity tests serve no far-reaching purpose to help children with autism identify their visual-spatial creative potential. By being able to measure real-world creativity in children with autism, this measure could potentially lead them to more fully identify their visual-spatial creativity, possibly leading them down more satisfying and productive roads in life.

Another strong point of this study is that the adapted creativity tool utilizes technology. Many children with ASD excel at visual spatial skills, so using SketchUp™, a 3D-modeling computer program, to measure their creativity gives these children the opportunity to express their creativity in an area in which they excel. It is also important to have creativity measures that reflect the technological advances of the time. Computers, software, modern medical equipment, theme parks, and apps, as well countless other technology-based inventions are showing that technology is becoming the foundation of our society. Creativity is a key factor in how these technological inventions came to fruition, and it would be beneficial to have a tool to measure creativity in this context.

Creativity is at the heart of all technological advances, and children would benefit greatly from learning how to use SketchUp™. SketchUp™ is a gateway program to many other 3D-modeling programs and could be a great tool to help all children better prepare for their futures in such a technology-based world. Google is the leader in the industry for jobs that correspond with visual-spatial creativity skills, and most architects, theme park designers, and video game designers have used or currently use SketchUp™ or programs like SketchUp™. Utilizing SketchUp™ as the means to test creativity may lead to children having future jobs in technology.

Since this is phase one of developing the new assessment tool, in the future we will retest with a control group. We foresee a neurotypical group of children being tested using both this new creativity assessment tool as well as an existing creativity test, like the CAP. If the total creativity scores correlate, it will provide further validity that this creativity tool assesses the construct of creativity. Future research could also examine test-retest reliability of the creativity scores derived from the assessment.

Using an existing creativity test as a comparison was not the focus of this study, but this research does provide opportunities for future research. To gather further data on how the creativity of children with ASD is measured using this new assessment tool, future research could expand the sample size to include youth with a wider range of IQs, older children, females, and a more limited range of diagnoses so that every child in the sample has an IEP that includes autism. A broader sample size could provide more reliability to this study. If future researchers wish to replicate this study, I recommend choosing to make every project a template in SketchUp™ before the participants begin creating. By doing this, every self-made object created in the project will then be uploaded to the 3D warehouse as a component, thus making it much easier to count self-made objects because SketchUp™ counts all components automatically. Future researchers could also compare this tool to other standardized creativity tests to determine if children with autism do perform more creatively when in a natural setting and when not asked to be creative on demand.

One of our goals in this study was to develop an authentic measure of creativity that could build on children with ASD's strengths. Although divergent-thinking tests have been criticized for their scores not crossing over into real-world settings, this adapted assessment tool not only plays to the strengths of children on the spectrum, but also makes that vital connection to creativity in the real world. Implications are that this test could be a creativity measure for children with ASD and be a creativity measure for employers to determine real-world creativity capabilities in their future employees, particularly employees on the spectrum.

APPENDIX

ADAPTED CREATIVITY ASSESSMENT TOOL

SketchUp™ Project Title: __________

Newbold Creativity Assessment Sheet

Step 1: Quickly go through the project and make notes about your first impressions. Then identify the main theme of the project.
Notes:

Theme: ____________________________________

Step 2:
1. Fluency—the ability to generate a large number of ideas.
Directions: Count the number of downloaded components by first clicking on "Window," "Model Info," "Statistics," and "Purge Unused." Then click on "Window," "Components," "Select," and the small image of a house to see images of all downloaded components. Count the number of images and write the number below. Then count the number of self-made objects by scrolling through the project using the select, pan, rotate, look around, zoom, and zoom extents tools, counting whatever you didn't see in the list of components. Write the number below (ex: Components—6 points; Self-Made Objects—4 points). Give 20 points if there are 20 or more components or self-made objects. **(20 points possible)**
Components—______ points
Self-Made Objects—______ points
______ total points

2. Flexibility—the ability to generate a broad range of ideas.
Direction: Using the select, pan, rotate, look around, zoom, and zoom extents tools, look through the project for objects that fall into the following categories:
Living—person, face, graphic character, plant, animal, etc.
Mechanical—car, spaceship, gun, toy, refrigerator, anything you plug in or needs batteries, etc.
Symbol—letter, number, name, flag, or anything expressing meaning
View—city, highway, surrounding scene, mountain, yard, park, etc.
Utility—house, box, building, aquarium, furniture, toilet, food, etc.
Elements of Nature—rain, a puddle, fire, explosion (i.e., cloud/smoke/flames), etc.

Circle "yes" if the project has at least one item that falls in that category, or circle "no" if the project has no items in that category. **(6 points possible)**

Living—		yes	no
Mechanical—	yes	no	
Symbol—	yes	no	
View—		yes	no
Utility—	yes	no	
Element of Nature—	yes	no	
	______ total points		

3. Originality—the ability to generate unique or unusual responses or ideas.

1. Combination of Components (5 points possible)

Directions: Give points for how downloaded components and/or self-made objects are shown together in nontypical ways (ex: 1 pt for floating words, different size people side by side, a My Little Pony on a large gun; and 0 pts points for a kitchen table w chairs, same size people side by side).

0pts No objects used in nontypical ways.
1pt One instance of objects being used or shown in a nontypical way.
2 pts Two instances of objects being used or shown in nontypical ways.
3 pts Three instances of objects being used or shown in nontypical ways.
4 pts Four instances of objects being used or shown in nontypical ways.
5 pts More than four instances of objects being used or shown in nontypical ways.
______ points

4. Elaboration—the ability to add new ideas and details to what already exists.

1. **Altered Components (3 points possible per component)**
Directions: Click on "Window," "Components," and the small image of a house to see images of all downloaded components. Look at the images of all components so that you know what the components originally looked like. Click on one of the images, and when you pull your mouse away you'll see the

component floating there. This will let you see the size the component would've come in as. Move the floating component next to the original component for size comparison. Take note of what the original looks like and then find it in the project to see if any changes were made to it (ex: Half of original component deleted).

0pts Component unaltered.
1pt Component altered by being shrunk, enlarged, flattened, upside down, etc.
2pts Component altered by something added to or taken away from it.
3pts Component altered in both ways listed above.

Comp 1	Comp 2	Comp 3	Comp 4	Comp 5	Comp 6
____pts	____pts	____pts	____pts	____pts	____pts
Comp 7	Comp 8	Comp 9	Comp 10	Comp 11	Comp 12
____pts	____pts	____pts	____pts	____pts	____pts

______ total points

*Note to remember: If the same component is downloaded into the project 5 times and all 5 are shrunk down to the same size, that is worth only 1 point. If the same component is downloaded into the project 5 times and all 5 are altered in 5 different ways, that is worth 5 points.

2. **Scene Angles (2 points possible, global rating for whole project)**
Directions: Click on "View," "Animation," and then "Play" to watch the scenes play (even if it looks like there may not be scenes). Give your impression of how elaborate the scene animations are as a whole—the process of how one scene gets to the next scene as well as the scene angle and the flow of scenes(ex: 1 pt for having basic scenes that get you from point A to point B very simply; and 2pts for scenes that serve a specific purpose, take us through the nose of a character, or show progression of a story, etc.).

0 pts No scenes.
1 pt Basic movements of scene angles.
2 pts Unique movements of scene angles.

______ points

3. **Scene Titles (3 points possible, global rating for whole project)**
   Directions: If there are scenes, notice the titles of the scenes. Then follow the point scale below.

   0 pts   No self-made title (ex: "Scene 1" or "Scene 2").
   1 pt   Simple title without modifier (ex: "The Dinosaur").
   2 pts   Title with descriptive modifier (ex: "The Hungry Dinosaur").
   3 pts   Title expressing name beyond what is shown in the scene (ex: "Say good-bye sucker!" or "The good ole days.").

   ______ points

Step 3: Complete this section after assessing all projects

Originality—the ability to generate unique or unusual responses or ideas.

2. Theme of SketchUp™ Projects (5 points possible)

Look at all of the projects in the sample. Based on the *theme* of the project, which you identified in Step 1 of the assessment, determine how *original* it is compared to the other projects in the sample. In this sample the most common themes were (1) army/halo/battles and (2) avatar the last air bender, with (3) dinosaurs and (4) Pokémon coming in close second. Score the project on a scale from 1 to 5, circling the number that best applies, 1 being not original and 5 being very original.

Not Original		Original		Very Original
1	2	3	4	5

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