Kyung Hee Kim

From: Kyung Hee Kim [kkim@wm.edu]
Sent: Monday, March 08, 2010 1:48 PM
To: 'Sullivan, Roberta D.'
Cc: 'Bonnie Cramond'; 'jlvant@wm.edu'
Subject: RE: Copyedited Chapter for Cambridge Handbook of Creativity
Attachments: 2010-3-8-Final Revision_Intelligence Chapter_21_Kim_Cramond_VanTassel-Baska.doc

I have attached our revision.
If you have any questions, please let me know.
Thanks.
Kyung Hee

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From: Sullivan, Roberta D. [mailto:Roberta.Sullivan@tufts.edu]
Sent: Tuesday, March 02, 2010 2:30 PM
To: kkim@wm.edu
Subject: FW: Copyedited Chapter for Cambridge Handbook of Creativity

Hello,

Per the e-mail below from James Kaufman, I am reminding you to submit your reviewed, production-ready files to me by March 9th.

Thank you much,
Roberta

From: James C. Kaufman [mailto:jamesckaufman@gmail.com]
Sent: Monday, February 22, 2010 2:06 PM
To: 'Kyung Hee Kim'
Cc: Sullivan, Roberta D.
Subject: Copyedited Chapter for Cambridge Handbook of Creativity

Dear Kyung Hee,
We now have the copyedited notes on your chapter for the Handbook.
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Please return the reviewed, production-ready files to Roberta Sullivan (Roberta.Sullivan@tufts.edu) by March 9, and let me know as soon as possible if you expect to have any difficulty meeting this date.

Please do not hesitate to contact me if you have any questions or concerns.
Thank you!!!

James

CN Chapter 21

CT The Relationship between Creativity and Intelligence

Kyung Hee Kim

Bonnie Cramond

Joyce VanTassel-Baska

A The Relationship between Creativity and Intelligence

Researchers have long pondered the relationship between intelligence and creativity, and practitioners have wondered about the importance of each construct in respect to what should be emphasized in schools to develop high level abilities. This chapter lays out what we know about each construct from research and how the two constructs relate to each other. It examines claims that intelligence and creativity are interrelated as well as claims suggesting they are separate constructs based on meta-analytic findings. Genetics research is also reviewed noting the prevalent view of the power of the environment impacting genetic potential. Research on intelligence testing is presented noting the relationship of IQ to life success and failure and national/cultural well-being and dominance. The savant syndrome is also discussed as an anomaly of intelligence. We also review creativity research on personality, the creative process, and its products. The chapter further explores evidence suggesting that creativity development for all students may be an important strategy for world societies to promote as they wish to elevate their quality of life.

B What Is Intelligence?

Intelligence is an ability to understand complex ideas, to adapt to the environment, to learn from experience, and to engage in reasoning to overcome obstacles (Neisser, 1996). Intelligence reflects an individual's capacities, shaped by experience and learning, and is often operationally defined by schools as the cognitive abilities that are measured by an IQ test. Thus, IQ is a measure of intelligence and is an acceptable proxy for intelligence, although it is not the same as intelligence. One of the differences between intelligence and IQ is that the latter is limited by what is measured, whereas, in a pure form, intelligence is complex and multidimensional.

B Genetic Influences on Intelligence

Research has been focused on whether there is a difference in intelligence in terms of genetic factors. The nature–nurture controversy continues to wage, with different researchers concluding different degrees of impact from genetics or environment. However, a series of studies by Plomin (1999) and his colleagues of twins reared apart (c.f., Petrill et al, 2004; Plomin, Fulker, Corley, & DeFries, 1997; Plomin, DeFries, McClearn, & McGuffin, 2001; Plomin & Spinath, 2004) has led him to conclude the following things about the heritability of intelligence. First, genetic influence increases rather than decreases during development. This seems counterintuitive, but Plomin explains it as due to the tendency of individuals to select and shape their environments to fit their genetic predispositions. Thus, an intense, bookish child may grow up to be an intense, solitary researcher because she selects highly academic and solitary activities and is able to do so more and more as she matures. Second, environmental influences that are shared by family members tend to decline until they are insignificant by the time individuals reach adolescence. In fact, van Leeuwen, van den Berg, and Boomsma (2008) concluded that environmental factors influencing IQ are not shared among siblings because each individual's environmental influences that matter are internalized differently. This relates to Plomin's third point, that even environmental factors are mediated by genetics. In other words, not only do individuals experience and internalize environmental factors differently depending on their genetic makeup, but their genetic tendencies also affect how the world reacts to and treats them. Fourth, genetic effects are broad rather than specific. The same genes are responsible for several cognitive abilities, giving credence to the concept of a general intellectual factor. And, fifth, the specific genes that are related to intellectual abilities are beginning to be identified through the Human Genome Project (Plomin & Spinath, 2004), although the research is still in its early stages. Ultimately, Plomin has recognized the mutual influences of genetics and environment, but he has argued that it is difficult to separate the two for study (Plomin & Price, 2003).

Thus, although individual differences in IQ are strongly attributed to genetic differences, the environmental effects of education over time have shown the capacity to raise IQ scores by at least 10 points (Finkel & Pedersen, 2001). Further, some researchers have observed that environmental factors may be more or less important depending on the level of intelligence. It has been noted that environment seems to be more influential for low-IQ individuals than high-IQ individuals (Finkel

& Pedersen, 2001; Jensen, 1970). Also, Plomin and Petrill (1997) advised that the etiology of intelligence may be different for low- and high-IQ individuals.

Plomin's assertions have not gone unanswered by those who take a different view. A series of responses by environmental psychologists in the March 1994 issue of *Social Development* argued for a much stronger emphasis on environment (Brofenbrenner & Ceci, 1994; Hoffman, 1994; McCall, 1994; Wachs, 1994), and Plomin responding in the same issue largely agreed (Plomin, 1994). All agreed that both nature and nurture impact development and behavior, they just did not necessarily agree on degree and cause. Further, Turkheimer, Haley, Waldron, D'Onofrio, and Gottesman (2003) suggested that the heritability of IQ varies with social class. They found that 60% of the variance in IQ is accounted for by the shared environment, and the contribution of genes is close to zero in low-SES families, whereas the result is the reverse in high-SES families. More recently, Richardson and Norgate (2006) took exception to many of the conclusions drawn from twin studies, such as those that informed Plomin and his colleagues, citing problems with methods as well as assumptions. They argued that the studies do not convincingly show that genetic and environmental influences are additive and that either genetics or environment can be shown to have independent influence on development. In addition, they argued that twin studies do not meet the conditions of random-effects design, and thus they violate the assumptions of the statistics used to substantiate them. Moore (2006) further argued that the studies are flawed in assuming causation from correlations. Some studies have indicated that an enriched environment can

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actually enhance brain development, and thus intelligence. Diamond (1988) was able to synthesize almost 30 years of research to show that a stimulating environment has a physiological effect on the brain. Similarly, Greenough, Black, and Wallace (1987) reviewed studies about the effects of environmental stimulation on the brain, effectively arguing that stimulating experiences impact neural growth and synapse connections.

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The extreme view for the preeminence of environmental effects over genetics on intelligence was proposed by the behaviorists, such as Skinner and Watson, but few psychologists take such a limited view any more. As Eysenck (1998) observed in his chapter entitled "Nature and nurture: The great partnership," "no serious scientists will argue for one or the other being singly responsible for human or animal behaviour. Both are always involved and interact in complex ways" (p. 47). Likewise, Halpern (1997) argued for a psychobiological model of intelligence in which the causes and effects of heredity and environment are circular (p. 1097).

B The Role of Intelligence in Economic Productivity

Much research has been done regarding possible effects of intelligence. It has been reported that the economic prosperity of both individuals and nations is related to their IQs. Jensen (1998) reported a positive relationship between one's childhood IQ and adult income. Murray (1998) also reported a positive relationship between one's adolescent IQ and early adult income. Not just individuals' intelligence, but countries' average intelligence is also the subject of research. Lynn and Vanhanen (2002) reported a positive relationship between average IQs among 185 countries and their economic prosperity measured by Gross Domestic Product per capita (GDP/c), although there have been criticisms of this work. The cognitive level of a nation measured by international student assessment studies such as the International Evaluation of Educational Achievement-Reading (IEA-Reading), the Trends in International Mathematics and Science Study (TIMSS), the Program for International Student Assessment (PISA), and the Progress in International Reading Literacy study (PIRLS) have been found to have a positive relationship with GDP (Rindermann, 2008; Wittmann & Hunt, 2008).

However, the effects of IQ on academic achievement are mediated by personality and learning approaches (Chamorro-Premuzic & Furnham, 2008). One's beliefs about the nature of intelligence affects motivation and achievement such that holding entity theory beliefs (e.g., that ability is stable and cannot be changed) was found to have a detrimental impact on academic achievement when compared to holding an incremental theory by which one believes that ability is malleable and can be developed (Cury, Fonseca, Zahn, & Elliot, 2008; Good, Aronson, & Inzlicht, 2003; Thompson & Musket, 2005).

One of the most widely used tests for making high-stakes decisions about educational opportunities, placements, and diagnoses is the Scholastic Aptitude Test (SAT), now called the Scholastic Assessment Test. Studies have shown the usefulness of the SAT as a predictor of success in college performance (e.g., Bridgeman, McCamley-jenkins, & Ervin, 2000), especially for early-college academic performance (Kuncel, Hezlett, & Ones, 2001). Other studies have shown the efficacy of this test for finding younger students who reason extraordinarily well in verbal and mathematical areas and who demonstrate higher evidence of creative productivity in professional domains than less able counterparts and comparison groups who were not so identified over 30 years later (Webb, Lubinski, & Benbow, 2007). Shorter-term academic growth patterns have been noted as well for students who receive advanced instruction, based on their SAT scores in the middle school years (Olszewski-Kubilius, 2006). IQ scores have also been found to be highly correlated to both the American College Test (ACT) and the SAT. The ACT is designed to be curriculum-based and to measure the preparedness of a student for more advanced education, whereas the SAT has traditionally been seen as a specific aptitude measure to assess verbal and mathematical reasoning abilities, especially when used with younger populations. Further, even though the ACT is used in college admissions decisions as an alternative to the SAT, it is not an aptitude test or an IQ test according to the ACT Newsroom (2010). However, because of the high correlations with IQ test scores, the ACT (Koenig, Frey, & Detterman, 2008) and the SAT (Frey & Detterman, 2004) appear to be good proxy measures of intelligence. Consequently, it can be said that colleges are making admission decisions based on a student's demonstrated achievement or aptitude, which is related to their IQ. Further, both the SAT I and SAT II results are found to be related to family income and parental education, favoring Caucasian and Asian students but disfavoring African-American, Hispanic, and Native American students (Kobrin, Camara, & Milewski, 2002). Studies suggesting that the SAT is biased against minority groups and not a strong prediction of college grades have led to its reduced use and change in format to a more achievement-oriented measure.

Gordon (1997) suggested that life outcomes can be traced to extreme levels of IQ scores, noting that higher education, higher income, and prestigious career choices favor high-IQ individuals, whereas crime, poverty, and unemployment relate to low-IQ individuals. However, it should be noted that other variables contribute strongly as well to life circumstance.

B Environmental Impacts on Intelligence

After re-examining the Lynn and Vanhanen's (2002) data set, Wittmann and Hunt (2008) question Lynn and Vanhanen's conclusion that intelligence causes a nation's well-being. Rather, Wittmann and Hunt suggested that, first, intelligence produces wealth; next, wealthier nations can provide better schools, health, and stable living conditions for students; and finally, these things improve cognitive competence. Ceci (1991; Ceci & Williams, 1997) also argued that education can improve childhood IQ through schooling, especially during early preschool and school years so that children can develop long-term positive attitudes toward learning. They also argued that early strategies to guide learning, parental and family attitudes about supporting education, and parents' and children's expectations for academic achievement are inculcated during this period. Further, Dickens and Flynn (2001) demonstrated how IQ can be improved by intellectual challenges. They explained that very large environmental effects can arise from iterative processes in which a small improvement leads to more challenge, which leads to further improvement resulting in higher challenges, which

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leads to even further improvement, and so on. In addition, Turkheimer et al. (2003) found that heritability of IQ depends on SES.

There is confusion about whether intelligence is decreasing or increasing. Genotypic intelligence has been defined as the genetic makeup of intelligence, and phenotypic intelligence is that which is demonstrated and can be measured by intelligence tests (Retherford & Sewell, 1988). There is evidence that phenotypic intelligence has been increasing. Flynn (1984) documented that IQs based on the test norms of the Stanford-Binet and Wechsler tests have increased in the United States over the decades of the last century. Flynn (2007) also documented the worldwide increase in IQs during the past century. He reported that IQs on the Raven's Matrices and on the Similarities subtest of the Wechsler Intelligence Scale for Children (WISC) have gained by about 25 points, and the IQs on the WISC Arithmetic, Information, and Vocabulary subtests have gained by about 3, which he indicated might be due to reduced inbreeding, improved nutrition, or increased affluence.

On the other hand, there is evidence that genotypic intelligence is decreasing. Galton (1869) warned earlier about the possibility that British people's as well as other developed nations' intelligence might decrease. Recently, Teasdale and Owen (2008) found that IQs are decreasing in highly developed countries. Herrnstein and Murray (1994) showed that nations' intelligence is decreasing by reporting that women with an average IQ of 111 had 1.6 children, whereas women with an average IQ of 81 had 2.6 children. Zajonc (1976, 1983, 2001a, 2001b) found negative relationships between intelligence and both family size and birth order. He explained

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that the smaller the number of children in the family, the greater attention they can get from their parents. Moreover, older siblings teach younger siblings, and this teaching role enhances the intelligence of older siblings starting at age 12, plus or minus 2 years (Zajonc, 2001a). Both Lentz (1927) and Cattell (1937) also showed the negative relationship between intelligence and family size, which has been known as dysgenic fertility. Dysgenic fertility has been confirmed in the United States (Lynn, 1996; Lynn & Van Court, 2004; Rodgers, Cleveland, Van den Oord, & Rowe, 2000; Vining, 1982, 1995) as well as in England, Scotland, and Greece (Lynn, 1996). Further, Shatz (2008) also reported a negative relationship between national IQ and national indicators of fertility in his cross-national study

Teasdale and Owen (2008) reported that most of the recent findings of the Flynn Effect for the phenotypic intelligence are from developed countries from the last century. They concluded that there is little evidence that the trend has continued in this century; moreover, they observed a decline in scores in a population of Danish males. Based on this conclusion and observation, they predicted that IQ scores will decrease and that the Flynn Effect is now almost at an end. In fact, Lynn and Harvey (2008) found that the increase of the world's phenotypic IQ has more than compensated for the decrease of the world's genotypic IQ between 1950 and 2000. Therefore, Shatz (2008) concluded that the environmental improvements responsible for the Flynn Effect are likely to diminish, and if dysgenic fertility continues, then phenotypic intelligence will begin to decrease.

B The Special Case of Savants: An Intelligence Anomaly

The real mystery of intelligence, and how little we know about it, is suggested by the idiosyncratic talents of individuals with Savant Syndrome. These individuals, whose condition was popularized by the 1988 movie *Rain Man*, have simultaneously extreme abilities and disabilities. Treffert and Wallace (2004) described savants as possessing "astonishing islands of ability and brilliance that stand in jarring juxtaposition to their overall mental handicap" (p. 3).

Peek, who was a model for the savant character in the movie *Rain Man*, has amassed great quantities of knowledge through his prolific reading and incredible powers of memory, and he has the savant ability to name days of the week for any calendar date. However, he lacks the ability to do the most basic self-care (bathing, shaving, brushing his teeth) and is perplexed by metaphors and other abstractions (Peek, 2007).

Even savants, similar in that they have amazing discrepancies in abilities, are dissimilar in the nature and degree of their functioning. Most have some type of autism or other developmental disorder (Treffert & Wallace, 2004). Unlike Kim Peek, Daniel Tammet is a very highly functioning savant who lives independently and has learned to respond socially (Tammet, 2007). Diagnosed with Asperger's Syndrome, a high-functioning type of autism, Tammet's remarkable abilities include being able to recite pi to more than 5,000 decimal places. The special abilities of savants are restricted to a few areas that seem to require extreme focus and memory skills; most commonly they have restricted abilities in music, art, calendar calculating, mathematics, and mechanical or spatial skills (Treffert, 2010, p. 3).

The existence of Savant Syndrome would be intriguing, but perhaps unworthy of widespread interest, if it merely reflected on the relatively few individuals so diagnosed. However, the nature and expression of savant abilities provide a way to view intelligence and brain functioning, especially in the light of their connection, or lack thereof, to creativity. Although almost exclusively restricted to right-hemisphere functions, they are primarily nonsymbolic and restricted to memory and motor functions (Treffert & Wallace, 2006). Therefore, the skills that they exhibit are performance and reproduction, not original creation and interpretation, the hallmarks of creativity.

What is Creativity?

An idea or product must be original to be considered creative, and at the same time, originality must be defined within a particular sociocultural group (Simonton, 1999) because what may be original in one society or culture may be common in other societies or cultures. What is original could be a breakthrough that causes a paradigm shift in a field or an important synthesis of existing thought in various forms (VanTassel-Baska, 1998). Moreover, the idea or product that is original cannot be considered as creative unless it has social value and appropriateness (Runco, 1993). Thus, creativity is the ability to produce work that is both original and appropriate or useful (Barron, 1988; 1995; MacKinnon, 1962) as judged by the culture at a given point in time, not by the originator (Simonton, 1999).

What are the conditions for creative productivity? According to Rhodes (1961), there are four Ps to explain the multifaceted construct of creativity – *Person*, *Process*, *Product*, and *Press*. *Person* includes cognitive abilities, biological traits, biographical traits, and personalogical traits; *Process* describes the mental processes operative in creating ideas, which include preparation, incubation, illumination, and verification (Wallas, 1926); *Product* includes ideas expressed in the form of language or craft; *Press* includes the relationship between a person and his or her environment (Rhodes, 1961). Creative products are the outcome of creative processes engaged in by creative persons, which is supported by creative press. Torrance (1988) started with research on the creative process and then asked what kind of person one must be to engage in the creative process successfully; what kind of environments (*Press*) will facilitate it; and what kinds of creative products will result from successful operation of the creative processes. More current creativity researchers have focused strongly on the environmental contexts that are conducive to creativity (Amabile, Schatzel, Moneta, & Kramer, 2004), the quality of the products that are created (Simonton, 1999), and the role of cultural acceptance of the innovation (Csikszentmihalyi, 2000).

B The Lack of Consensus about the Relationship between Creativity and Intelligence

Research on the relationship between creativity and intelligence has been a topic of interest to researchers for a long time, but there has been no clear consensus among the researchers yet. Guilford (1967) was the first researcher to develop a taxonomy of human abilities, called the Structure of Intellect (SOI), in which creative thinking was prominently featured as a part of intellectual functioning. He argued that traditional intelligence tests do not sufficiently measure creative abilities, and he hypothesized that creative individuals possess divergent thinking abilities including idea production, fluency, flexibility, and originality. Many studies (e.g., Getzels & Jackson, 1958; Torrance, 1977a; Furnham & Bachtiar, 2008; Furnham & Chamorro-Premuzic, 2006) have been conducted illustrating that creativity and intelligence have low correlations; that is, a highly intelligent person is not necessarily highly creative. Further, Guilford's (1967) theories spawned an array of divergent-thinking or creativity tests such as the Torrance Tests of Creative Thinking, Wallach & Kogan Divergent Thinking Tasks, and the Guilford Divergent Thinking Tasks. They also spawned research that correlate scores on these divergent-thinking tests with creative potential. However, in general, creativity tests do not carry political weight compared to IQ tests: Creativity tests are sometimes used for identifying gifted students for programs, but the impact of creativity scores on the decision counts less than that of IQ (Kaufman & Baer, 2006).

Cattell and Horn (Cattell, 1943, 1971; Horn & Cattell, 1966) did not separate the two concepts of creativity and intelligence and divided intelligence into crystallized intelligence (gC) and fluid intelligence (gF). According to Cattell, (1943, 1971), gC is the ability to use skills, knowledge, and experience, and to gain, retain, structure, and conceptualize information, which can be measured by tests of general knowledge and verbal comprehension, whereas gF is the ability to draw inferences and understand the relationships of concepts, which can be measured by tests of abstract reasoning. Cattell (1971) argued that creative performance is determined first by one's gF and then by one's personality factors. Later, Furnham, Batey, Anand, and Manfield (2008) found that gF is specifically related to more divergent-thinking fluency than self-rated creativity or the inventory of creative behaviors.

Recently, Cattell-Horn's gC and gF theory has been combined with Caroll's (1993) Three-Stratum Theory, which is called the Cattell-Horn-Carroll (CHC) theory. There are some differences between the Cattell-Horn's and the Caroll's theories, including the presence (for Caroll's, but not for Cattell-Horn's) of a g factor or a general intellectual factor. However, the CHC theory has emerged as the consensus psychometric-based models for understanding the structure of human intelligence (McGrew, 2009) and is the intelligence theory that is most used in IQ tests (Kaufman, 2009). The CHC theory consists of the 16 different broad abilities (McGrew, 2009): Ga (auditory processing), Gc (comprehension knowledge; the breadth and depth of a person's accumulated knowledge of a culture and the ability to use that knowledge to solve problems), Gf (fluid reasoning; the ability to solve novel problems), Gh (tactile abilities), Gk (kinesthetic abilities), Gkn (general [domain-specific] knowledge), Glr (long-term storage and retrieval), Go (olfactory abilities), Gp (psychomotor abilities), Gps (psychomotor speed), Gq (quantitative knowledge), Grw (reading and writing), Gs (processing speed), Gsm (short-term memory), Gt (reaction and decision speed), and Gv (visual processing). Although the CHC theory does not specify creativity, creativity seems to be a primary component of its Gf (Kaufman, 2009).

In 1993, Gardner focused on the idea of eminence, which requires sustained creative productivity over time. He analyzed the lives of seven eminent creative individuals of the twentieth century, each of whom specialized in one of his multiple intelligences. Gardner (1995) has argued that intelligence is a multifaceted collection of eight distinct intelligences and that creativity is the highest level of application of these intelligences.

Renzulli's (1986) three-ring conception of giftedness suggested that giftedness is at the intersection of above-average ability (intelligence), creativity, and task commitment, in which creativity and intelligence are components of giftedness. On the contrary, Sternberg and Lubart's (1991) investment theory of creativity suggested that intelligence is a subset of creativity and that there are six elements that combine to form creativity: intelligence, knowledge, thinking styles, personality, motivation, and environment. Both of these models value creativity as the more relevant concept to giftedness.

Many researchers in the field (e.g., Barron, 1961; Guilford, 1967; MacKinnon, 1961, 1967; Simonton, 1994) agree with the "threshold theory," which assumes that above an IQ score of 120 there is no correlation between measured creativity and intelligence. The threshold theory agrees with the assertion that creativity and intelligence are separate constructs above a minimum level of IQ 120. However, there have been only a few studies that systematically investigated the

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threshold theory, and results are inconclusive (Runco, 1991). Kim's meta-analysis (2005) found that the relationship between creativity and intelligence is negligible at any IQ level, which undermines the threshold theory and supports the underlying belief that creativity and intelligence are separate constructs. The threshold theory was further investigated using structural-equation modeling but was not supported (Preckel, Holling, & Wiese, 2006). Moreover, Park, Lubinski, and Benbow (2007) found that the threshold theory is not supported by their data either.

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Kim (2005) found that the relationship between creativity and intelligence among younger children was weaker than for any other age groups, which might be because of little educational influence over the use of their cognitive abilities. Some studies (e.g., Iscoe & Pierce-Jones, 1964, Wallach & Kogan, 1965) indicated that the correlations between creativity and IQ measures are significantly increased when creativity tests are administered as serious tests rather than as a fun activity, especially for kindergarten or children in the early elementary years. In fact, Kim's (2005) meta-analysis found that scores on the Wallach and Kogan Divergent Thinking Tasks had a weaker relationship to intelligence than any other creativity tests had, which might be because the Wallach and Kogan Divergent Thinking Tasks are administered as non-testlike and untimed, a common and positive aspect of creativity testing. Therefore, Kaufman and Baer (2003) concluded that creativity tests are often administered as serious tests under a timed condition, which may have led to poor convergent validity among creativity test scores and poor discriminant validity between creativity test scores and IQ test scores.

B The Role of Personality

According to Silvia (2008), personality variables confound correlations between intelligence and creativity, suggesting that personality may be a part of the creative process. Personality variables such as openness to experience predict both IQ (DeYoung, Peterson, & Higgins, 2005) and creativity (Feist, 1998). Openness to experience is found to be the most influential factor on intelligence (Furnham & Thomas, 2004; Furnham & Chamorro-Premuzic, 2006), especially on gC and is even more strongly related to creativity (McCarthy, 1987; Miller & Tal, 2007). However, according to Furnham and Chamorro-Premuzic (2006), openness to experience is positively related to gF but not related to general intelligence. Harris (2001) also reported that openness was related to intelligence; however, creativity was a subscale of the intelligence factor in his study.

Neuroticism as related to anxiety, hostility, and depression are found to be negatively related to intelligence (Ackerman & Heggestad, 1997). Neuroticism is also negatively related to scientific creativity but positively related to artistic creativity (Götz & Götz, 1979).

Agreeableness in personality traits such as trust, modesty, and compliance is found not to be related to intelligence (Ackerman & Heggestad, 1997). Conscientiousness is found to be weakly related to intelligence (Zeidner & Matthews, 2000) but negatively related to creativity (Furnham & Chamorro-Premuzic, 2006).

Feist's (1998) meta-analysis reported that creative people tend to be autonomous and introverted, open to new experiences, norm-doubting, self-

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confident, self-accepting, driven, ambitious, dominant, hostile, and impulsive. After an extensive literature review, Batey and Furnham (2006) found that the most common personality traits that are related to creativity are confidence, independence, and openness to new ideas. Eminent creators have had a certain level of knowledge to advance in a field, although there is a curvilinear relationship between knowledge and creativity, which indicates that too much knowledge leads to entrenchment and an inability to conceive of the field in a radically different light (Batey & Furnham, 2006; Sternberg & Lubart, 1995).

Feist (1998) found that openness to experience and extraversion are the characteristics that most strongly distinguish creative from noncreative scientists. In addition, he found that conscientiousness, conventionality, and closed-mindedness tend to be negatively related to being a creative scientist. Extraversion was found to be strongly related to four measures of creativity (Furnham & Bachtiar, 2008) – Guilford's (1967) unusual uses divergent thinking test, the biographical inventory of creative behaviors (see Batey, 2007), a self-rated measure of creativity (see Batey, 2007), and the Barron-Welsh Art Scale (Welsh, 1987).

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B Creativity and Intelligence: Studies of Brain Activity

Modern technologies have allowed researchers to gain information about brain processing that was not possible before. Specifically, Electroencephalography (EEG) is used for measuring electrical activity produced by the brain using electrodes on the scalp to indicate levels of brain activity. Thus, an EEG may be used to show differences in brain activity in different stages of wakefulness or active problem solving. The other new technology is Functional Magnetic Resonance Imaging (fMRI), which measures changes in blood flow related to brain activity, showing the areas of the brain that are activated during certain tasks.

Different patterns of EEG are produced between divergent-thinking tasks and convergent-thinking tasks (Fink & Neubauer, 2006; Jaušovec, 2000; Mölle, Marshall, Wolf, Fehm, & Born, 1999; Razoumnikova, 2000): Creative problem-solving tasks produce synchronization of alpha activity, typical of wakeful relaxation, whereas convergent tasks produce desynchronization of alpha activity (Fink & Neubauer, 2006). Higher EEG complexity is documented when divergent-thinking tasks are being administered to subjects as opposed to convergent thinking tasks (Mölle et al., 1999). The highly creative group showed more decoupling of brain areas, whereas the highly intelligent showed a more intense cooperation between brain areas when resting (Jaušovec & Jaušovec, 2000). Jaušovec (2000) found that, when engaged in creative problem solving, the highly creative showed less mental activity than the less creative, and the highly creative showed more cooperation between brain regions than the highly intelligent.

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Through the combined use of fMRI and EEG, Jung-Beeman and colleagues (c.f. Jung-Beeman, Bowden, Haberman, Frymiare, Arambel-Liu, Greenblatt, Reber, & Kounios, 2004) scanned people's brains while they solved different types of puzzles. They found that the combined use of these technologies gave them both good spatial information (fMRI) and good temporal information (EEG) to understand what was happening in the brain, when and where, during problem solving that requires insight. Thus, they have been able to observe what parts of the brain are activated during different stages of problem solving and when solving problems with insight, where the answer suddenly seems to appear out of nowhere, versus solving problems through systematic analysis. Most strikingly, the brain measurement technologies show that when solving insight problems, an individual's realization of a solution is preceded by a burst of brain activity. In fact, 300 milliseconds before a participant communicates the answer, the EEG registers a spike of gamma rhythm — the highest electrical frequency of the brain. Also, the anterior superior temporal gyrus (aSTG), a small area on the surface of the right hemisphere, becomes unusually active in the second before the insight. Such brain information illustrates physiological differences in methods of problem solving that may be related to differences between creativity and intelligence.

B Distinctions between Creativity and Intelligence

Highly creative individuals may or may not be the same as highly intelligent individuals. Compared with highly intelligent individuals, highly creative individuals have distinctive characteristics conducive to originating creative ideas or products. Some of these characteristics are conducive to having difficulties in traditional school settings. Many highly creative students have trouble in traditional school environments (Cramond, 1995; Amabile, 1989). Sixty percent of 400 eminent people had serious school problems (Goertzel & Goertzel, 1960). Torrance (Gowan, Khatena, & Torrance, 1979) referred to highly creative students as "creatively handicapped" because their creativity may make their achievement in traditional

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classrooms difficult, although creativity can be an asset in their lives. The energy of Thomas Edison and Nikola Tesla got them into trouble in childhood but helped them when working the long hours on their creative tasks (Cramond, 1995). Virginia Woolf and Samuel Taylor Coleridge were well known as being constant talkers in childhood, which is a characteristic of creative individuals and is often a problem in school, but their verbal ability was an asset to their creative tasks of writing (Cramond & Kim, 2007). When highly creative students are forced into traditional school environments, they routinely become troublesome to teachers, disruptive in the classroom, and resent the constraining structure of the classroom, excessive rules and regulations, and the press for conformity.

Teachers often prefer students who are achievers and teacher pleasers rather than disruptive or unconventional creative students (Davis & Rimm, 1994; Rudowicz, 2003; Rudowicz & Yue, 2000; Scott, 1999), even among the teachers who value creativity (Hunsaker, 1994; Westby & Dawson, 1995). Many teachers see creative children as a source of interference and disruption (Scott, 1999), and thus teachers' judgment of their favorite students is negatively related with creativity, and they may tend to devalue their students' creative behaviors even when they highly value creativity (Westby & Dawson, 1995). Similarly, Hunsaker (1994) found that teachers' observations for nomination for a gifted program focused more on classroom performance than on creativity, even when teachers proclaim that they highly value the construct of creativity. Many teachers prefer students with a high IQ to students who are both highly creative and intelligent (Anderson, 1961). Teachers rate students with high IQs as more desirable, better known, or understood, and more studious than students with high creativity (Torrance, 1962).

Using the checklist that Torrance (1975) created to assess attitudes toward creative children, Singh (1987) found that parents did not respond favorably to the personality characteristics of creative children. However, such perceptions can vary with time and place. In 1984, Douglas, Jenkins-Friedman, and Tollefson found that teachers' views of creative personality characteristics had changed from those that Torrance had measured 20 years earlier. They found that teachers who completed the Ideal Child Checklist were more likely to value independence, courage, sincerity, and personal initiative than had the teachers in the earlier study who indicated that they favored more conforming and socially acceptable behaviors. In Eastern societies, the top-ranked traits for an ideal student were honest, self-disciplined, responsible, and respectful of parents; these characteristics were followed by diligent, unselfish, humble, and obedient (e.g., Rudowicz, 2003; Rudowicz & Yue, 2000).

Teachers' views are important in that teachers have the power to promote students' creativity directly through using creative-thinking strategies, by encouraging intrinsic motivation, and by providing opportunities for choice and discovery as well as imagination and fantasy (Schacter, Thum, & Zifkin, 2006). Fostering creativity should not be just for high-IQ students, but for every student. Russo (2004) found that high-IQ students were not different from regular students in creativity scores at either pretest or posttest after 6 months of the Future Problem

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Solving program, and both high-IQ students and regular students benefit from creativity and problem-solving skills training.

B The Value-Added Aspect of Creativity

Because achievement tests in school settings assess rote knowledge and skills and do not measure higher-level executive functions including abstract thinking, creative thinking, and problem solving (Delis et al., 2007; Gardner, 1993; Sternberg, 1985), it is important to consider value-added assessment approaches that do provide data on how students process information at high levels. Sternberg, Grigorenko, and Jarvin, (2006) argued that one important goal for future study should be creating standardized tests that reduce ethnic group differences but still maintain test validity. Sternberg and his Rainbow Project collaborators (2006) have argued that analytical abilities are necessary but not sufficient for college success, and that creative and practical skills are needed for success in school and life. Therefore, based on his triarchic theory of successful intelligence, Sternberg et al. (2006) developed a supplementary assessment for analytical, practical, and creative skills to augment the role of the SAT in predicting students' college success. They found that the measure enhanced predictive validity for college GPA and substantially reduced ethnic group differences compared to high school GPA and the SAT.

This indicates that adding assessments for practical and creative skills to traditional analytical skills can be effective in predicting college success and can be fairer to students from diverse cultures. Creativity assessment allows students to respond from their own knowledge rather than from predetermined knowledge and is,

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therefore, potentially fairer to students from diverse cultures, especially when the assessment minimizes verbal components (Jellen & Urban, 1989; Torrance, 1977b; Voss, 1998). Evidence from data collected statewide on the effects of the Georgia multiple criteria rule for identifying students (Georgia Department of Education, 2010) supports the effectiveness of adding creativity assessments for identifying gifted students, especially those from underserved populations (Williams, 2000). The addition of a creativity assessment as an option to meet the standards for identification has been very helpful in identifying students from underserved populations (Krisel & Cowan, 1997).

B The Future Primacy of the Concept of Creativity

A society in which independence, ownership, and democracy are encouraged is beneficial to individuals' intrinsic motivation and thus creativity (Amabile, 1996). Florida (2002) concluded that the key to any country's prosperity is its ability to attract creative people. DiPietro (2004) reported positive relationships among the creativity index from the World Economic Forum (2000), the IQ from Lynn and Vanhanen's report (2002), and the freedom index on political rights and on civil liberties. DiPietro explained that although high IQ enables a country to be capable of creativity, the extent of freedom on political rights and on civil liberties in a country determines the degree to which creativity is not confined and, therefore, has the opportunity to flourish. It takes time to change a society into one that encourages creativity. However, even when micro environments such as classroom settings, teaching styles, and assessments are changed into ones that encourage creativity and

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intrinsic motivation, students' creativity can be improved (Dineen & Niu, 2008). This situation carries positive implications for the role of creativity in schools if teachers and other educators are willing to open up the curriculum and instructional process to ensure that creative challenge is the rule and not the exception.

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