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General, Artistic and Scientific Creativity Attributes of Engineering and Music Students

Christine Charyton and Glenn E. Snelbecker
Temple University

ABSTRACT: The purpose of this research was to investigate similarities and differences in general, artistic, and scientific creativity between engineering versus music students, as 2 groups respectively representing scientific and artistic domains. One hundred music and 105 engineering students from a large, Northeastern university completed measures of general creativity, music creativity, engineering creativity, and a demographic questionnaire. Results indicated that musicians scored higher in general and artistic creativity, with no significant differences in scientific creativity. Participants had higher levels of creativity, compared with normative data from previous studies. Gender, age, and specialization within major yielded no significant differences. Implications for creativity measures are discussed, including cognitive risk tolerance.

Snow (1959) noticed some attributes of scientists and artists that made them seem to be living in two different cultures, although also sharing some common qualities. Prospects for identifying creativity attributes among scientists, as well as artists, have been explored periodically by various authors (Feist, 1999; Feist and Barron, 2003; Helson 1996), and have indicated a need for further investigation of creativity in these two cultures. Questions that motivated our investigation included the following: What similarities and differences are there in general, artistic, and scientific creativity among engineering and music undergraduate students? How do these engineering and music majors compare with published normative test information? To what extent are there similarities and differences within each major? What creativity differences are functions of demographic characteristics (gender, ethnicity and age) among engineering and music students?

The Nature of Artistic and Scientific Creativity

Simonton, as quoted in Kersting (2003), seemed to acknowledge the existence of differences, as well as possible similarities in creativity between scientist and artists when he stated: "Science has to be constrained to scientific process, but there's a lot less constraint on artists. Many artists come from more chaotic environments, which prepares them to create with less structure" (p. 40). According to Simonton (1999), "Researchers often treat creativity as a single, relatively homogeneous phenomenon" (p. 639). Somewhat in contrast, Gardner (1999) stated, "People are creative when they can solve problems, create products, or raise issues in a domain in a way that is initially novel

Christine Charyton is now at Department of Psychology, the Ohio State University at Newark.

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Correspondence should be sent to Christine Charyton, Department of Psychology, The Ohio State University at Newark, 1179 University Drive, Newark, OH 43055. E-mail: charyton.1@osu.edu

but is eventually accepted in one or more cultural settings'' (p. 116). Gardner's views seem to support the idea that creativity can take different forms in different domains. Thus, it may be conceptually and practically important to know about differences, as well as similarities, of creativity among engineers versus musicians.

Cognitive and disposition profiles tend to vary according to the type of creative achievement (Feist, 1999; Simonton, 1999). Larson, Thomas, and Leviness (1999) noted the possibility that creativity in engineering might be different from creativity in literature, painting, and other professions. ''A distinguishing feature is that the engineer has an eye on function and utility. Therefore, there may be a creative engineer versus a creative sculptor, painter, poet or musician'' (p. 2). Weisberg (1995) stated that the basis for creativity is problem solving. This problem solving process is common in both artistic and scientific fields, although it may take different forms.

Some researchers have attempted to understand similarities and differences regarding artistic versus scientific creativity by focusing on personality attributes. ''Certain personality traits consistently covary with creativity, yet there are some domain specificities'' (Feist, 1999, p. 289). As a result of meta-analysis, Feist (1999) identified social and nonsocial traits in art and science domains from recent theories of Eysenck (1994), Russ (1993), Busse and Mansfield (1984), and the five-factor model. Social traits for the artist included norm doubting, nonconformity, independence, hostility, aloofness, unfriendliness, and lack of warmth. Social traits of scientific creative personality included dominance, arrogance, hostility, and high self-confidence. It appears that aesthetic taste and a lack of conventionality are common characteristics of creativity in both domains (Feist, 1998, 1999; Simonton, 1999; Sternberg, 1986).

Helson (1996), MacKinnon (1962), and Simonton (1999) are some of the researchers who had investigated art and science domain differences. MacKinnon, an earlier researcher, reported that the creator in scientific creativity acts as a mediator between externally defined needs and goals, but in artistic creativity, the creator externalizes something of himself or herself into the public field. When studying artists and scientists, MacKinnon emphasized architects and mathematicians, because architecture design requires the practitioner to be both an artist and a scientist. Helson, using the Holland (1966) hexagon system for analyzing occupational potential, reported that creativity was most likely to be found among people with artistic interests, followed by investigative, social, and enterprising personalities. According to Helson, creativity is least likely in realistic and conventional personalities. From her research, it would seem reasonable that engineering students may be less likely than music students to display creativity. According to Simonton, ''creative scientists tend to exhibit traits that fall somewhere between those of the creative artist and those of the average human being'' (p. 639). One logical extention, beyond what Helson and Simonton stated, would be to predict that engineers and musicians may differ in some attributes that are specific, respectively, to science and art domains.

Feist and Barron (2003), from a longitudinal study starting when respondents were graduate students, found that creative individuals tended to be more autonomous, introverted, open to new experiences, norm-doubting, self-confident, and self-accepting. They concluded, ''The participants who became the most creative over the course of their lives were self-controlling, independent, self-assured, spontaneous, responsible, tried to make a good impression on others, relatively low in hypomania and hostility'' (p. 80). Feist and Barron (2003) observed that ''these findings contradict other studies that have reported arrogance and hostility to be associated with creative scientists'' (p. 81).

It is plausible that some of these creativity attributes may be common in both engineering and music domains (Charyton, 2005). Perhaps literature has emphasized differences; however, similarities in scientific and artistic creativity may also be prevalent. Therefore, in our study, we chose to investigate potential similarities, by using measures of general creativity attributes, and potential differences by also using domain specific creativity measures.

Furthermore, risk taking may be an attribute that affects creativity, thus we included a measure of cognitive risk tolerance for assessment. Farley

(1991) commented that "creativity in science, art and many fields, [is] the sort of productive risk taking [that] has been a hallmark of America from its beginnings" (p. 375). The concept of risk tolerance has been central to decision making in finance, investments, and financial planning (Roszkowski & Snelbecker, 1990). Snelbecker, Roszkowski, and Cutler (1990) proposed a conceptual model and developed a set of scales to assess investors' risk tolerance and return aspirations (Roszkowski, Snelbecker, & Leimberg, 1989). A measure of cognitive risk tolerance (Snelbecker, McConlogue, & Feldman, 2001) was developed as an extension of that model and set of scales. Feldman (one of the creators of the cognitive risk tolerance scale) noted: "[Cognitive risk tolerance is] an individual's ability to formulate and express one's ideas despite the threat of negative assessment regarding: reputation, integrity, credibility, honor and intelligence" (Feldman, 2003, p. 6). Using the Cognitive Risk Tolerance Survey, Feldman (2003) found cognitive risk tolerance to be moderately related to, but different from, two so-called positive psychology variables: academic hardiness and emotional intelligence.

Additionally, the present authors viewed cognitive risk tolerance as a potentially relevant attribute or component of creativity. In previous research (Feldman, 2003), the Cognitive Risk Tolerance Scale was also moderately correlated with two other positive psychology attributes, academic hardiness and emotional intelligence. Risk taking has been described by others (Farley, 1991) as a necessary component of creativity. However, our series of literature reviews did not reveal relevant research findings about the risk taking in general, nor of cognitive risk tolerance in particular, for creativity. In our study, cognitive risk tolerance was included as a construct to be measured in regard to general creativity. Although various authors have mentioned risk as a component of influence on creativity, the only cognitive risk tolerance instrument found during the literature reviews was the research version of the Cognitive Risk Tolerance Survey (Snelbecker, McConologue, & Feldman, 2001). Therefore, it seems plausible that cognitive risk tolerance might be related to creativity among engineers as well as musicians.

Measurement of Musicians' and Engineers' Creativity

Initially, we attempted to identify existing scientific creativity and artistic creativity measures, but were not very successful in finding such instruments. Various resources were reviewed to identify potentially useful measures, respectively, of engineers' and musicians' creativity. In addition to conducting literature searches of psychology, social science, technology, education, and other databases, we also contacted relevant faculty members, specialized librarians, and others who might provide leads to such instruments. Wherever feasible, we contacted authors or vendors of instruments that might be useful for this study.

We first searched for information about creativity measures for musicians, because it seemed likely that more measures might be available for musicians' creativity than for engineers' creativity. Despite extensive searches, we found very few appropriate instruments. Music creativity researchers apparently have tended to utilize the divergent versus convergent thinking processes or have focused on creative products (Hickey, 2001; Hong, Milgram, & Gorsky, 1995; Runco, 1986). According to Hickey, consensual assessment is one approach that has been used to assess the extent to which music products or outcomes are "creative"; consensual assessment involves the extent to which there is interrater agreement of a creative product. However, Hickey notes that the "use of consensual assessment for measuring musical creativity is recent and limited" (p. 236).

There are similarly limited measures designed specifically to assess engineers' creativity. Researchers (Goodman, Furcon, & Rose, 1969; Sprecher, 1963) made early attempts to assess engineering creativity, with productivity surveys and tests, but no generally accepted measure of engineers' creativity resulted from that work. Larson, Thomas, and Leviness (1999) used the Myers Briggs Type Indicator (MBTI) and Torrance tests to assess engineers' creativity, but apparently they were not satisfied with the MBTI as a measure of creativity. A series of literature reviews revealed that some attempts had been made to measure engineers' scientific creativity or engineering creativity, but only limited reports were found and efforts to contact those researchers were not successful (Gupta, 1988; Majumbar, 1975; Shukla & Sharma, 1987, 1986). After review of the information that could be found, the present authors concluded that the Purdue Creativity Test, designed to measure the potential of engineers to be creative in their career (Lawshe & Harris, 1960), was an appropriate measure for this study. Larson (one of the researchers cited above) indicated both support for and interest in our project and our selected measures. Based on his own research and professional experiences, Larson suggested that that both originality and practicality (or, usefulness) might be a unique attribute of engineering creativity (M. Larson, personal communication, August 14, 2003).

Measurement of General Creativity

Based on information from previous research, the present authors hypothesized that engineers and musicians would demonstrate approximately equivalent levels of general creativity, that engineers would demonstrate higher levels of scientific creativity, and that musicians would demonstrate higher levels of artistic creativity. Normative data and demographic information (where available) were used to provide some perspective about the levels of creativity indicated by respondents in this research. Additionally, it was expected that students with some specializations (i.e., within the engineering major and within the music major) might display more creativity than other specializations, respectively, within each major.

Methodology

Participants

Data were collected from 105 engineering students and 100 music students from a large Northeastern university. First, Institutional Review Board approval was obtained for the research. School/college administrators and faculty members reviewed the proposal and granted permission for recruiting engineering and music students. Instructors of the courses were contacted after communicating with these departments to solicit permission to administer the instruments. Missing data were handled by pairwise deletions. The number of missing cases per variable ranged from 0 (the Harmonic Improvisation Readiness Record, Purdue Creativity Test, Creativity Personality Scale, Creativity Temperament Scale) to 8 (Cognitive Risk Tolerance Scale).

Procedure

Participants were provided oral and written descriptions of the nature of the study and given opportunities to ask questions. They were informed that participation was strictly voluntary and anonymous, with the provision that they could refuse to participate at any time. Participants were instructed to return consent forms separately, prior to test administration, to maintain confidentiality. Each set of materials was coded with a number to ensure objectivity and anonymity. All measures were administered according to the instructions for each test. Last, participants were thanked and given light refreshments for their time, as a token of appreciation.

Instruments

A questionnaire was administered requesting demographic information. This included age, gender, ethnicity, major, and specialization area within the major. Additional questions for all participants addressed the extent expected to be creative in their particular career, whether they typically would follow instructions or develop their own design, and whether they were in the band or choir in high school.

Creative personality scale (CPS). The CPS of the Adjective Checklist (ACL; Gough, 1979) was administered to assess creativity attributes. This test for creative thinking was chosen because it is highly regarded, reliable and widely used as a creativity test. For example, Plucker and Renzulli (1999) stated,

> Oldham and Cummings (1996) in a comparison of personality traits, environmental characteristics, and product ratings, found evidence that people with specific personality traits (i.e., as judged by Gough's [1979]

Creativity Personality Scale) produced creative products when challenged by their work and supervised in a supportive 'noncontrolling fashion' (p. 609), (p. 46).

Creative temperament scale (CT). The CT adapted from the California Psychological Inventory (CPI; Gough, 1992) was designed to assess personality characteristics and predict what people will say and do in specific contexts. The CT is one of the special purpose scales of the CPI. Gough, gave permission to extract the CT from the CPI (H. Gough, personal communication, June 28, 2003). Split-halves reliability indicated .73. Items were found to correlate with observers' rating of creativity (.44). Gough (1992) stated that "the CT scale correlated with .33 with the overall composite for creativity [and] the overall rating of creativity for this sample correlated .47 with the scores of the CT" (p. 245). Ratings of creativity of engineering honor students also pooled yielded a correlation of .53 with the CT (Gough, 1992).

Cognitive risk tolerance survey (CRT). The CRT (Snelbecker, McConolgue, & Teitlebaum, 2001) consists of 35 self-report items to assess an individual's ability to formulate and express one's ideas despite potential opposition. Responses are on a Likert Scale ranging from 0 (*very strongly disagree*) to 9 (*very strongly agree*). Higher scores indicate higher levels of cognitive risk tolerance. The CRT was developed as an extension of an earlier risk tolerance model developed by Snelbecker and colleagues (Roszkowski, Snelbecker, & Leimberg, 1989; Snelbecker, Roszkowski, & Cutler, 1990). Reliability of this psychometric instrument has proven to be adequate with a Cronbach's alpha coefficient at .76 during Feldman's (2003) pilot study with 78 respondents, and a Cronbach's alpha coefficient of .78 during the main section of her dissertation study with 84 respondents.

Harmonic improvisation readiness record (HIRR). Gordon (2000) stated that "improvisation began to sustain the serious interest of music educators and psychologists, primarily under the guise of creativity, near the middle of the century" (p. 5). Kiehn (2003) stated, "Music composition and improvisation activities are considered developmentally important and a part of a comprehensive music program" (p. 278) and furthermore, that "there is a need for more research that focuses on music improvisation and related assessment procedures" (p. 279). Gordon (2000) operated on the premise that "all improvisation to some extent involves creativity, and all creativity to some extent involves improvisation" (p. 8). Therefore, we pursued using Gordon's measure as an appropriate indicator of music creativity.

Gordon's (1998) HIRR is a paper and pencil test designed for students grades 3 and above to determine a student's ability to audiate harmonic patterns and predict a student's potential (aptitude) to improvise harmonically. Means, standard deviations, standard errors, reliability coefficients (split-halves and Kuder-Richardson), item difficulty, and item discrimination levels were reported in the test manual. Item difficulty ranges from .85 to .20 for the HIRR. Gordon (2000) indicated a validity coefficient of .45 of the HIRR with students' recorded improvisations.

Purdue creativity test. The Purdue Creativity Test was developed "to aid in the selection and placement of engineering personnel who must produce original ideas to solve problems in their jobs" (Lawshe & Harris, 1960, p. 1). Internal consistency and scoring reliability were reported by two scorers for 64 professional engineers. In our study, we selected the Form G, because the authors stated that both versions (Form G and Form H) could be used interchangeably. Reliability estimates regarding internal consistency were flexibility (12 items), $r = .86$; fluency (8 items), $r = .93$; and the total score (20 items), $r = .95$ (Lawshe & Harris, 1960). Reliability estimates regarding interscorer agreement were flexibility (agreement in categorizing decisions about different types of responses), $r = .87$, and total scores (Flexibility $+ \frac{1}{2}$ Fluency), $r = .97$. (Interscorer reliability for fluency was not reported because it is a count of responses.) Concurrent validity evidence was based on the extent to which Purdue Creativity Test scores were predictive of their supervisors' ratings of high versus low on-the-job creativity (e.g., produce new and original ideas when confronted with problem situations). Data were obtained from each of three engineer groups—Group 1, 33 auto product

Table 1. *Descriptive Statistics for Creativity Variables and Cognitive Risk Tolerance by Major*

	Engineering			Music			Total Group	
Dependent Variable	*n*	*M*	*SD*	*n*	*M*	*SD*	*M*	*SD*
Creativity Personality Scale	99	5.36	4.11	97	6.61	3.92	5.98	4.05
Creativity Temperament Scale	99	21.74	4.89	97	24.61	4.89	23.16	5.04
Cognitive Risk Tolerance Scale	99	193.32	35.57	97	192.37	34.55	192.35	34.98
Harmonic Improvisation Readiness Record	105	28.48	7.77	99	33.23	6.16	30.78	7.41
Purdue Creativity Test	105	74.14	36.36	99	76.89	34.72	75.48	34.72

engineers; Group 2, 29 process engineers, and Group 3, 42 automotive design engineers. Chances of high on-the-job creativity ratings from high versus low test scoring engineers were 63% versus 35% for Group 1, 74% versus 29% for Group 2, and 62% versus 52% for Group 3.

Results

Similarities and Differences Between Engineers and Musicians

Similarities and differences in general, scientific, and artistic creativity among engineering and music undergraduate students were examined. A MANOVA was used to detect differences between engineering and music students in terms of three general creativity measures (creative attributes, creative temperament, and cognitive risk tolerance). Separate ANOVAs were used to detect differences between engineering and music students in terms of music (HIRR), and engineering creativity (Purdue Creativity Test). All participants took both engineering and music creativity measures. Table 1 contains means and standard deviations, respectively, for the engineering and music students for the CPS, CT, CRT, HIRR, and Purdue Creativity Test.

A two-way MANOVA was calculated examining the effect of major (engineering and music) on general creativity measures. A significant effect was found, *Lambda*(3, 192) = 7.17, $p = .000$, indicating that musicians had higher levels of general creativity. A one-way ANOVA was calculated comparing engineers and musicians in music (artistic) creativity. A significant difference was found, $F(1) = 23.30$, $p = .000$, indicating that musicians had higher levels of music creativity. A one-way ANOVA was calculated comparing engineers and musicians in engineering (scientific) creativity. No significant difference was found, $F(1) = .32$, $p = .574$, in terms of engineering creativity.

Our Data Compared with Normative Data Sets

Data from these samples of engineering and music majors were compared with published normative test information for general, artistic, and scientific creativity. In general, all four groups in our sample had higher or equivalent levels of creativity than the published norms. Where standard deviations and means were provided for the respective test norms, one-way ANOVAs were used to analyze statistical differences between the present four groups and the normative data. Where percentiles were included, respective samples of this study were compared with these normative percentiles.

Table 2 compares normative data with the means and standard deviations of the sample data. The Purdue Creativity Test normative data included the scores associated with each percentile, but did not provide means and standard deviations. The creativity scores at the 5th, 50th, and 95th percentiles for our four groups were compared with the 5th, 50th, and 95th percentiles' Purdue Creativity Test normative data. The CRT did not have available normative data.

CPS

A one-way ANOVA indicated a significant difference among engineers, musicians and CPS norms, $F(2) = 23.36$, $p = .000$. Tukey posthoc analysis indicated that only the male musicians

Table 2. *Comparison of Present Results with Normative Data*

Data	Mean	SD
Creativity Personality Scale		
Engineering sample		
Men[a]	5.19	4.06
Women[b]	6.17	4.36
Music sample		
Men[c]	7.13	3.97
Women[d]	6.10	3.84
Norms		
Men[e]	3.57	3.99
Women[f]	4.40	4.07
Creativity Temperament Scale		
Engineering sample		
Men[a]	21.74	4.92
Women[b]	21.72	4.90
Music sample		
Men[c]	24.96	4.50
Women[d]	24.27	5.07
Norms		
Men[g]	22.65	5.46
Women[h]	23.67	5.12
Harmonic Improvisation Readiness Record		
Engineering sample		
Men[i]	28.18	8.11
Women[j]	29.89	5.81
Music sample		
Men[j]	32.84	6.64
Women[d]	33.63	5.68
Norms[k]	27.80	6.12

Data	5th Percentile	50th Percentile	95th Percentile
Purdue Creativity Test			
Engineering sample			
Men[i]	23.60	78.00	133.20
Women[b]	20.35	74.50	135.00
Music sample			
Men[d]	20.00	75.00	137.20
Women[j]	20.00	68.00	137.75
Norms[l]	38.00	63.00	92.00

Note. [a]$n = 81$, [b]$n = 18$, [c]$n = 48$, [d]$n = 49$, [e]$n = 1078$, [f]$n = 1631$, [g]$n = 3235$, [h]$n = 4126$, [i]$n = 87$, [j]$n = 50$, [k]$n = 15000$, [l]$n = 106$.

were significantly different (higher than) the normative data ($p = .010$) compared with male engineers. Another one-way ANOVA indicated significant differences among female engineers and female musicians and CT norms, $F(2) = 1.63$, $p = .003$. Tukey posthoc analysis indicated that only female musicians ($p = .011$) were significantly different from (higher than) the CPS normative data.

CT

A one-way ANOVA indicated a significant difference among male engineers, male musicians, and CT norms, $F(2) = 5.42$, $p = .004$. Tukey posthoc analysis indicated that only the male musicians were significantly different (higher than) the normative data ($p = .010$). Another one-way ANOVA indicated no significant differences among female engineers, female musicians, and CT norms, $F(2) = 1.63$, $p = .196$.

CRT

Normative data were not available on this newly developed instrument.

HIRR

A one-way ANOVA indicated a significant difference among male engineers, male musicians, and HIRR norms, $F(2) = 16.82$, $p = .000$. Tukey posthoc analysis indicated that only male musicians were significantly different (higher than) the normative data ($p = .000$). Successively, another one-way ANOVA was calculated and indicated a significant difference among female engineers, female musicians, and HIRR norms, $F(2) = 23.12$, $p = .000$. Tukey posthoc analysis indicated that only female musicians were significantly different (higher than) the normative data ($p = .000$).

Purdue Creativity Test

The Purdue Creativity Test Technical Manual provided values of scores at selected percentiles but did not include other descriptive statistics. Thus, the present data sets were compared with norm information, respectively, at the 5th (norm = 38), 50th (norm = 63), and 95th (norm = 92) percentiles (Table 2). Engineers: males at the 5th (23.60), 50th (78.00), and 95th (133.20) and females at the 5th (20.35), 50th (74.50) and 95th (135.00) compared with the musicians: males 5th (20.00), 50th (75.00), and 95th (137.20) and females 5th (20.00), 50th (68.00), and 95th (137.75). In the absence of statistical tests, all four groups tended to be lower than the norms at the 5th percentile, higher than the norms at 50th percentile, and clearly seemed to be higher at the 95th percentile. In our study, all four groups tended to cover a wider range than did the norm group. At both extremes (5th and 95th percentiles), all four groups tended to cover a more expansive range: both lower and higher than the norms, respectively.

Comparison of Specializations Within Each of the Two Majors

Attempts were made to detect possible differences across specializations within each of the two majors, Engineering and Music. This was done because, as noted above in the literature review, it seems plausible that some engineers might be expected to be more creative than other engineers, and that some musicians might be more creative than other musicians. However, our original attempts to find independent indicators of expected levels of creativity yielded somewhat contradictory views. Thus, we decided to detect whether specializations within each of the majors might show differences in creativity.

Table 3 provides descriptive statistics for differences among engineering specialization groups (electrical, mechanical, and civil/environmental/chemical/marine), and among music specializations (education, jazz/composition, opera/performance/voice, and Other: therapy/technology). Groups were identified based on similarities in content and sample sizes per group.

Table 3. *Descriptive Statistics for Creativity Variables and Cognitive Risk Tolerance by Major and Specialization*

Dependent Variable	*M*	*SD*
Engineering (Electrical)		
Creativity Personality scale (CPS)[a]	5.51	4.29
Creativity Temperament scale (CT)[a]	20.97	4.75
Cognitive Risk Tolerance scale (CRT)[a]	197.21	37.27
Harmonic Improvisation Readiness Record (HIRR)[b]	28.79	8.89
Purdue Creativity Test[b]	69.40	32.59
Engineering (Mechanical)		
CPS[c]	5.80	3.94
CT[c]	22.88	4.91
CRT[c]	190.68	43.71
HIRR[d]	28.39	5.37
Purdue Creativity Test[d]	87.96	47.53
Engineering (Civil/Environmental/Chemical/Marine)		
CPS[e]	4.73	4.18
CT[e]	21.93	5.04
CRT[e]	186.40	27.31
HIRR[e]	27.83	8.31
Purdue Creativity Test[e]	68.73	25.37
Music (Education)		
CPS[f]	6.40	4.26
CT[f]	23.49	4.87
CRT[f]	184.57	41.63
HIRR[f]	33.97	5.08
Purdue Creativity Test[g]	81.69	29.11
Music (Jazz/Composition)		
CPS[h]	6.54	4.47
CT[h]	24.31	3.35
CRT[h]	187.23	34.16
HIRR[i]	35.00	5.37
Purdue Creativity Test[j]	60.64	23.63
Music (Opera/Performance/Voice)		
CPS[i]	6.47	3.18
CT[i]	27.73	4.20
CRT[i]	213.07	20.22
HIRR[i]	35.87	6.13
Purdue Creativity Test[i]	71.60	37.06
Music (Other: Therapy/Technology)		
CPS[h]	6.08	2.60
CT[h]	24.31	4.48
CRT[h]	186.15	19.93
HIRR[h]	34.62	6.06
Purdue Creativity Test[h]	78.54	34.74

Note. [a]$n = 39$, [b]$n = 42$, [c]$n = 25$, [d]$n = 28$, [e]$n = 30$, [f]$n = 35$, [g]$n = 36$, [h]$n = 13$, [i]$n = 15$, [j]$n = 14$.

For the three general creativity measures, separate two-way MANOVAs were calculated examining the effect of specialization within each major in terms of general creativity measures (CPS, CT, and CRT). No significant effect was found for engineering specializations, *Lambda*(6, 176) = 1.05, $p = .398$, nor for music specializations, *Lambda*(9, 173) = 1.63, $p = .111$.

For engineering and music creativity, separate two-way ANOVAs were calculated, respectively, across music specializations and across engineering specializations in terms of music creativity (HIRR). No significant difference was found for engineering specializations, $F(2) = .13$, $p = .880$, nor for music specializations, $F(3) = 17.90$, $p = .632$. Separate two-way ANOVAs were calculated across music specializations and across engineering specializations in terms of engineering creativity (Purdue Creativity Test). No significant difference was found for engineering specializations, $F(2) = 2.82$, $p = .065$, nor for music specializations, $F(3) = 1.87$, $p = .143$.

Demographic Characteristics of Participants

Levels of general, artistic, and scientific creativity were investigated in regard to demographic characteristics (gender, ethnicity, and age). Separate MANOVAs were used to investigate demographics (gender, ethnicity, and age) independently. A MANOVA was used to detect differences between engineering and music students in each demographic attribute separately (gender, ethnicity, or age) in three creativity measures (creative attributes, creative temperament, and cognitive risk tolerance). Separate ANOVAs were used to detect differences in engineering and music majors for artistic (HIRR), and engineering creativity (Purdue Creativity Test) within each separate demographic variable (gender, ethnicity, or age).

Gender. No significant effect was found from a two-way MANOVA examining the effect of major by gender (male and female) on general creativity measures (CPS, CT, CRT), $Lambda(3, 190) = 1.32$, $p = .270$. No significant effect was found from a two-way ANOVA comparing gender (male and female) in music creativity (HIRR), $F(1) = 1.17$, $p = .281$. No significant effect was found from a two-way ANOVA comparing gender (male and female) in engineering creativity (Purdue Creativity Test), $F(1) = .24$, $p = .628$.

Ethnicity. Table 4 provided descriptive statistics for ethnicity differences in creativity. Due to the limited number of minority participants (31% of musicians and 61% of engineers), ethnicity was coded as Caucasian or Other (African American, Latino, Asian, American Indian, Biracial, Multiracial and Other). A two-way (major by ethnicity) MANOVA was calculated examining the effect of ethnicity (Caucasian and Other) on general creativity variables. A significant effect was found, $Lambda(3, 190) = 2.88$, $p = .037$. Follow-up discriminant analyses indicated that only creativity temperament was significant for Caucasians, $Lambda(3, 197) = 20.24$, $p = .000$.

A two-way ANOVA (major by ethnicity) was calculated for music creativity. No significant differences were found from the two-way ANOVA (major by ethnicity) in music creativity (HIRR), $F(1) = 3.77$, $p = .054$. No significant interaction effect was found, $F(1) = .491$, $p = .484$.

A two-way ANOVA (major and ethnicity) calculated for engineering creativity (Purdue Creativity Test) indicated higher engineering creativity for Caucasians, $F(1) = 4.01$, $p = .047$. No

Table 4. *Descriptive Statistics for Creativity Variables and Cognitive Risk Tolerance by Major and Ethnicity*

	Engineering			Music		
Dependent Variable	**n**	**M**	**SD**	**n**	**M**	**SD**
Caucasian						
Creativity Personality Scale (CPS)	51	6.16	4.27	83	6.76	4.06
Creativity Temperament Scale (CT)	51	23.33	4.95	81	24.75	4.64
Cognitive Risk Tolerance Scale (CRT)	51	198.14	25.74	81	191.52	34.61
Harmonic Improvisation Readiness Record (HIRR)	54	27.74	8.40	83	32.78	6.03
Purdue Creativity Test	54	83.19	31.49	83	77.64	32.75
Other (African American, Latino, Asian, American Indian, Biracial, Multiracial, Other)						
Creativity Personality Scale (CPS)	48	4.52	3.79	14	5.71	2.92
Creativity Temperament Scale (CT)	48	20.04	4.25	14	23.79	5.70
Cognitive Risk Tolerance Scale (CRT)	49	186.15	43.10	14	197.43	35.03
Harmonic Improvisation Readiness Record (HIRR)	51	29.25	7.03	14	36.00	6.49
Purdue Creativity Test	51	64.57	38.95	14	72.36	35.50

interaction effect was found for major by ethnicity, $F(1) = 1.25$, $p = .265$.

Age. Table 5 provides descriptive statistics for differences within each major (engineering and music) across age groups (18–20, 21–25, 26–30 and 31+), based on sample sizes per group. A two-way MANOVA was calculated examining the effect of age groups (18–20, 21–25, 26–30 and 31+) on general creativity measures (CPS, CT, CRT); no significant effect was found, *Lambda*(9, 453) = .52, $p = .864$. A two-way ANOVA was calculated comparing age (18–20, 21–25, 26–30 and 31+) in music creativity (HIRR); no significant difference was found, $F(3) = 1.25$, $p = .293$. A two-way ANOVA calculated comparing age groups (18–20, 21–25, 26–30 and 31+) on engineering creativity (Purdue Creativity Test) revealed no significant differences ($F(3) = .88$, $p = .452$).

Instrument Correlations

Correlations among the instruments were conducted to identify their relationships with each other. Table 5 shows that the CPS, CT and CRT are moderately related to each other ($r = -.35$, $p < .01$, $r = .34$, $p < .01$, $r = .36$, $p < .01$). The HIRR had very low correlations with the other instruments. The Purdue Creativity test had slightly lower correlations with the general creativity measures than were the correlations among the general creativity measures.

Table 5. *Intercorrelations for Creativity Personality Scale (CPS), Creativity Temperament Scale (CT), Cognitive Risk Tolerance Scale (CRT), Harmonic Improvisation Readiness Record (HIRR), and Purdue Creativity Test*

Measure	1	2	3	4	5
Engineering					
CPS[a]	–				
CT[a]	.38**	–			
CRT[b]	.40**	.35**	–		
HIRR[a]	−.08	−.08	−.02	–	
Purdue Creativity Test[a]	.38**	.29**	.14**	.06	–
Music					
CPS[b]	–				
CT[b]	.26*	–			
CRT[c]	.33**	.36**	–		
HIRR[b]	.12	.06	.24*	–	
Purdue Creativity Test[b]	.17	.20*	.26**	.10	–
Total Group					
CPS[d]	–				
CT[d]	.35**	–			
CRT[e]	.36**	.34**	–		
HIRR[f]	.06	.07	.09	–	
Purdue Creativity Test[d]	.29**	.26**	.19**	−.02	–

Note. [a]$n = 105$, [b]$n = 99$, [c]$n = 97$, [d]$n = 204$, [e]$n = 196$, [f]$n = 205$.
*$p < .05$. **$p < .01$.

Discussion

Our first research question concerned differences between engineers and musicians in terms of general, artistic, and scientific creativity. First, as anticipated, the musicians had statistically higher levels in all three attributes of general creativity: creative attributes, creative temperament, and cognitive risk tolerance. However, the average scores on all three measures of general creativity were not exceptionally different for engineers versus musicians. Second, as anticipated, musicians had higher levels of music creativity than did engineers. However, again the differences between these two groups were modest. Third, although we anticipated that engineers would have higher levels of scientific creativity than musicians, there was no significant difference between groups on this variable.

As was noted above, various authors (Helson, 1996; Kersting, 2003; Simonton, 1999) have contended or suggested that artists have higher creativity levels than do scientists and engineers. But the present findings, although showing statistically significant differences on some measures, do not indicate that there are substantial creativity differences between engineers and musicians. Thus, it seems reasonable to explore whether some engineers or scientists may have higher levels of creativity, using the present measures, or through other measures. Based on the present results, and consistent with conclusions by Larson, Thomas, and Leviness (1999), there are serious questions about (a) the extent to which existing measures adequately detect creativity types and levels among engineers and (b) whether we have been able to identify or designate where differences among engineers or engineering specializations may reflect need for creativity. Perhaps instruments yet to be developed may actually reveal higher levels of engineering creativity than are reflected in the present study.

Analyses for the second research question showed that both engineers and musicians had higher than respective norm groups regarding general, artistic and scientific creativity. There were some within-major across-gender differences on some creativity variables. Male engineers and musicians had higher levels of creativity temperament than the normative data, but female engineers' and musicians' levels of creativity temperament were not higher than the norms. Male musicians (but not male engineers), as well as female engineers and female musicians, had significantly higher artistic (music) creativity than the norms. Like Gordon's (2000) results with college students, our college students (engineers and musicians) had higher means than Gordon's (1998) high school student norm data regarding music creativity. Only percentile data (but not means or standard deviation data) were available for the Purdue Creativity Test norms, thus limiting the kinds of comparisons that could be done. The engineers (as well as the musicians) had particularly high levels and a wider range of engineering creativity as compared with normative information. However, it must be noted that the most recent Purdue Creativity Test norm data that are available were published in 1960; thus we don't know whether updated norms would or would not be different today.

The third research question addressed potential differences with each major (within the engineer group and within the musician group). Feist (1998) suggested that there is a need to investigate whether there may be within-group differences in creativity. Larson, Thomas, and Leviness (1999) found that some types of engineers exhibited higher levels of creativity than other engineers. In the present study, no differences were detected across engineering specializations or across musician specializations.

Our fourth research question concerned potential creativity differences as a function of demographic characteristics (gender, ethnicity, and age) among engineers and musicians. No significant differences were detected in general, artistic, or scientific creativity between males and females, or across age groups. These findings contradict former statements by Greenacre (1960) that females tend to have inferior creativity abilities. The present results support more recent findings of Hassler, Nieschlag, and de la Motte (1990), indicating that females display equivalent levels of creativity with their male counterparts. Our study indicated that Caucasians had significantly higher levels of general creativity than minority groups. However, Caucasians and minorities did not differ in relation to music creativity levels. Through our literature reviews, we did not find other previous studies with which we could compare our findings about general, artistic, and scientific creativity regarding age and ethnicity, specifically.

Relationships were examined among measures of the creativity variables addressed in this study. Relationships between the creative personality and the creative temperament measures are of interest for practical, as well as conceptual, reasons because they often have been used to measure creativity in studies through administration of the CPI or the ACL (Feist, 1998; Feist & Barron, 2003; Gough, 1979; Gough & Bradley, 2002; Helson, 1996; Helson, Roberts, & Agronick, 1995). The moderate correlation between these two measures suggests that researchers might obtain different results, depending on which measure is used. Additionally, it is of interest that cognitive risk tolerance was correlated with these two variables at about the same level that CPS and CPT are correlated with each other. We propose that cognitive risk tolerance may be a component of general creativity that is likely to be moderately related to, but different from, other general creativity measures. Other relationships among the creativity are also reported but did not seem to reveal any particularly important information.

Conclusions and Implications

The present authors agree with Simonton's (1999) concern that "researchers often treat creativity as a single, relatively homogenous phenomenon" (p. 639). Our study was founded on the premises that (a) creativity may involve different types (general, artistic, and scientific creativity), (b) certain types of creativity may be different across different professional groups (engineers and musicians) or domains, (c) some forms of creativity may exist generally without regard to domain, and (d) it is important to include both general and specific measures of creativity when comparing professional groups and other groups of people in society. It should be noted that the present study did not address measures of creative products or performance measures, but rather focused on attitudes and views that can be useful indicators of differing levels of creativity among people, both within and across domains. The present authors propose that CRT may constitute a necessary and useful addition to usual conceptions and measures of general creativity.

It is noteworthy that engineering and music faculty members emphasized both the need for and interest in assessing creativity within their respective domains. The present authors attempted to find the most appropriate, reliable, and valid instruments that were available. The instruments that were selected did provide some useful information, but experiences during this study also raise questions about the status of these instruments and other currently available creativity measures. Music creativity did not seem to be as closely related to the other creativity measures as had been expected. Similarly engineering creativity had significant yet low correlations with the general creativity measures.

The fact that there were no statistically significant differences between engineers and musicians in terms of engineering creativity is puzzling. The present study's results may accurately reflect the nature of these types of creativity and their interrelationships. However, it is also plausible that the existing instruments were simply not adequate for assessing engineering and music creativity. For example, existing measures may not adequately detect the kinds of creativity that are very important for design engineers, which may be different or the same across engineering subdomains and specializations.

Problems and limitations encountered during the present study indicate the need for instruments that, respectively, address music creativity and engineering creativity both within those domains and in multiple domain areas. The need for assessing engineering creativity and for assessing music creativity still exist, both for practical reasons and for understanding the nature of creativity in all of its forms.

References

Busse, T. V., & Mansfield, M. S. (1984). Selected personality traits and achievement in male scientists. *The Journal of Psychology*, 116, 117–131.

Charyton, C. (2005). *Creativity (Scientific, artistic, general) and risk tolerance among engineering and music students*. (Doctoral dissertation, Temple University, 2004).

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York: Harper Collins.

Eysenck, H. J. (1994). Creativity and personality: Word association, origence, and psychoticism. *Creativity Research Journal*, *7*, 209–216.

Farley, F. (1991). The type-T personality. In L. P. Lipsitt & L. L. Mitnick (Eds.), *Self-regulatory behavior and risk taking: Causes and consequences* (pp. 371–382). Norwood, NJ: Ablex.

Feist, G. J. (1998). A meta-analysis of personality in scientific and artistic creativity. *Personality and Social Psychology Review*, *2*, 290–309.

Feist, G. J. (1999). The influence of personality on artistic and scientific creativity. In R. J. Sternberg (Ed.), *Handbook of creativity*. Cambridge, UK: Cambridge University Press.

Feist, G. J., & Barron, F. X. (2003). Predicting creativity from early to late adulthood: Intellect, potential and personality. *Journal of Research in Personality*, *37*, 62–88.

Feldman, J. M. (2003). *The relationship among college freshmen's cognitive risk tolerance, academic hardiness, and emotional intelligence and their usefulness in predicting academic outcomes*. (Doctoral dissertation, Temple University, 2003).

Gardner, H. (1999). *Intelligence reframed: Multiple intelligence for the 21st century*. New York: Basic Books.

Getzels, J. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art*. New York: John Wiley & Sons.

Gordon, E. E. (1998). *Harmonic improvisation readiness record and rhythm improvisation readiness record*. Chicago: GIA Publications.

Gordon, E. E. (2000). *Studies in harmonic and rhythm improvisation readiness*. Chicago: GIA Publications.

Gough, H. G. (1979). A creative personality scale for the adjective check list. *Journal of Personality and Social Psychology*, *37*, 1398–1405.

Gough, H. G. (1992). Assessment of creative potential in psychology and the development of a creative temperament scale for the CPI. In J. C. Rosen & P. McReynolds (Eds.), *Advances in psychology assessment* (pp. 225–257). New York: Plenum.

Gough, H. G., & Bradley, P. (2002). *CPI Manual: Third edition 2002 printing: California Psychological Inventory*. Palo Alto, CA: Consulting Psychologists Press.

Greenacre, P. (1960). Woman as artist. *Psychoanalytic Quarterly*, *29*, 208–227.

Gupta, S. M. (1988). Distribution of scientific creativity ability. *Indian Journal of Psychometry and Education*, *19*, 21–24.

Hassler, M., Nieschlag, E., & de la Motte, D. (1990). Creative musical talent, cognitive functioning and gender: Psychobiological aspects. *Music Perception*, *8*, 35–48.

Helson, R. (1996). Arnheim Award address to division 10 of the American Psychological Association: In search of the creative personality. *Creativity Research Journal*, *9*, 295–306.

Helson, R., Roberts, B., & Agronick, G. (1995). Enduringness and change in creative personality and prediction of occupational creativity. *Journal of Personality and Social Psychology*, *69*, 1173–1183.

Hickey, M. (2001). An application of Amabile's consensual assessment technique for rating the creativity of children's musical compositions. *Journal of Research in Music Education*, *49*, 234–244.

Holland, J. L. (1966). A psychological classification scheme for vocations and major fields. *Journal of Counseling Psychology*, *13*, 278–288.

Hong, E., Milgram, R. M., & Gorsky, H. (1995). Original thinking as a predictor of creative performance in young children. *Roeper Review*, *18*, 147–149.

Kersting, K. (2003). Considering creativity: What exactly is creativity? *American Psychological Association Monitor*, *34*, 40.

Kiehn, M. (2003). Development of music creativity among elementary school students. *Journal of Research in Music Education*, *51*, 278–288.

Larson, M. C., Thomas, B., & Leviness, P. O. (1999). Assessing the creativity of engineers. *Design Engineering Division: Successes in Engineering Design Education, Design Engineering*, *102*, 1–6.

Lawshe, C. H., & Harris, D. H. (1960). *Manual of instructions to accompany Purdue Creativity Test forms G and H*. Princeton, NJ: Educational Testing Services.

MacKinnon, D. W. (1962). The nature and nurture of creative talent. *American Psychologist*, *17*, 484–495.

Majumbar, S. K. (1975). A systems approach to identification and nurture of scientific creativity. *Journal of Indian Education*, *1*, 17–23.

Oldham, G. R., & Cummings, A. (1996). Employee creativity: Personal and contextual factors at work. *Academy of Management Journal*, *39*, 607–634.

Plucker, J. A., & Renzulli, J. S. (1999). Psychometric approaches to the study of human creativity. In R. J. Sternberg (Ed.), *Handbook of creativity*. Cambridge, UK: Cambridge University Press.

Roszkowski, M. J., & Snelbecker, G. E. (1990). Effects of "framing" on measures of risk tolerance: Financial planners are not immune. *The Journal of Behavioral Economics*, *19*, 237–246.

Roszkowski, M. J., Snelbecker, G. E., & Leimberg, S. R. (1989). Risk tolerance and risk aversion. In S. R. Leimberg (Ed.), *The tools and techniques of financial planning*. Cincinnati, OH: National Underwriter Company.

Runco, M. (1986). Divergent thinking and creative performance in gifted and nongifted children. *Educational & Psychological Measurement*, *46*, 375–384.

Russ, S. (1993). *Affect and creativity: The role of affect and play in the creative process*. Hillsdale, NJ: Lawrence Elrbaum Associates, Inc.

Shukla, J. P., & Sharma, V. P. (1987). A cross cultural student of scientific creativity. *Indian Journal of Applied Psychology*, *24*, 101–106.

Shukla, J. P., & Sharma, V. P. (1986). Sex differences in scientific creativity. *Indian Psychological Review*, *30*, 32–35.

Simonton, D. K. (1999). Creativity and genius. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research*. New York: Guilford.

Snelbecker, G. E., McConologue, T., & Feldman, J. M. (2001). *Cognitive risk tolerance survey*. Unpublished manuscript.

Snelbecker, G. E., Roszkowski, M. J., & Cutler, N. E. (1990). Investors' risk tolerance and return aspirations, and financial advisors' interpretations: A conceptual model and exploratory data. *Journal of Behavioral Economics*, *19*, 377–393.

Snow, C. P. (1959). *The two cultures and the scientific revolution*. New York: Cambridge University Press.

Sprecher, T. B. (1963). A proposal for identifying the meaning of creativity. In C. W. Taylor & F. Barron (Eds.), *Scientific creativity: Its recognition and development* (pp. 77–88). New York: John Wiley & Sons.

Sternberg, R. J. (1986). Intelligence, wisdom and creativity: Three is better than one. *Educational Psychologist*, *21*, 175–190.

Sternberg, R. J., & Lubart, T. I. (1999). The concepts of creativity: Prospects and paradigms. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 3–15). Cambridge, UK: Cambridge University Press.

Weisberg, R. W. (1995). Case studies of creative thinking: Reproduction versus reconstructing in the real world. In S. M. Smith, T. B. Ward, & R. A. Finke (Eds.), *The creative cognition approach* (pp. 53–72). Cambridge, MA: MIT Press.