

The Effect Size of Variables Associated With Creativity: A Meta-Analysis

Hsen-Hsing Ma

Department of Education, National Chengchi University, Taiwan

The main purpose of this study was to use meta-analysis to investigate the mean effect size of relevant variables associated with creative person, process, product, and environment. Altogether, 2,013 effect sizes from 111 studies were analyzed. The unweighted grand mean effect size of the 111 studies was 0.69, with a standard deviation (*SD*) of 0.63. Such result was significantly different from 0 at $t(110) = 11.52, p < .01$. When the averaged effect size of each study was weighted with the sample size of that study, the weighted grand mean effect size was 0.72. The important findings were: (a) the mean effect sizes associated with problem-solving creativity and verbal creativity were significantly larger than those associated with emotional creativity and nonverbal creativity, (b) variables having a large mean effect size were prestige of honors/awards, working circumstances favorable for creativity, defining problem, and retrieving knowledge, (c) most of the mean effect sizes of the problem solving procedures on the measures of problem solving exceeded the medium (0.5) of Cohen's guidelines. Areas to be further explored are suggested.

Three directions can be identified in the literature on creativity research: (a) to evaluate the effectiveness of creativity training, (b) to determine the environmental factors that nurture or inhibit creativity, and (c) to find the association of creativity with personal factors such as cognitive ability and/or with personality (Basadur, Graen, & Green, 1982). For the direction (a), studies have been conducted to evaluate the effectiveness of creativity training programs by synthetic analysis of the overall effectiveness of such programs by means of narrative review (Mansfield, Busse, & Krepelka, 1978; Torrance, 1972) or quantitative meta-analysis (Ma, 2006; Miga, Burger, Hetland, & Winner, 2000; Rose & Lin, 1984; Scope, 1998; Scott, Leritz, & Mumford, 2004a, 2004b; Swanson, & Hoskyn, 1998). The present

study intended to investigate the directions (b) and (c), that is, the association of creativity with environmental and personal factors.

There has been one meta-analysis investigating the correlates of creativity (Feist, 1998). Feist (1998) investigated the associations between creativity and personality by comparing scientists with nonscientists, more creative with less creative scientists, and artists with nonartists, and found that creative people are more open to new experiences, less conscientious, more self-accepting, hostile, and impulsive. These traits had large effect sizes (over 0.8) on creativity. Can Feist's (1998) findings be generalized to populations beyond scientists and artists?

Sternberg and Lubart (1995) have proposed six resources that nurture creativity: intelligence, knowledge, thinking style, personality, motivation, and environment. With the exception of environment, the other five resources belong to the category of creative person. Han (2000) defined creativity in terms of three Ps: the creative person, the creative process, and the creative product. Creative person is similar to an independent variable that can influence the creativity and creative product is equivalent to a dependent variable that is a measure of creativity. The present study classified the

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Correspondence should be sent to Hsen-Hsing Ma, Department of Education, National Chengchi University, Wen-Shan District (116), Chi-nan Road, Section 2, No. 64, Taipei City, Taiwan. E-mail: gxyzwgc@nccu.edu.tw

measures of creativity into (a) creativity with less evaluation, including nonverbal and verbal; (b) creativity in problem solving, with more evaluation; and (c) emotional creativity, and tried to compare the relative mean effect size of other variables associated with them. What follows is a brief review and rationale for each of the "three Ps," of person, process, and product, as applied for use in this meta-analysis.

CREATIVE PERSON

A creative person may be described with reference to personality characteristics, demographical characteristics, intelligence, cognitive ability, school performance and achievement, cognitive styles, thinking styles, motivation, attitude, and background experiences.

For personality, the classification of five broad dimensions of personality proposed by Digman (1990) can be represented by the acronym OCEAN, which stands for openness, conscientiousness, extroversion, agreeableness, and neuroticism. These denote openness to experience versus satisfaction with the familiar, conscientiousness versus indifference, extroversion versus introversion, agreeableness versus hostility, and neuroticism versus emotional stability. Among the Big Five personality traits, neuroticism has to be mentioned specifically here. Neuroticism is normally regarded as a negative trait in a personality. However, research findings concerning the relationship between neuroticism and creativity were not consistent (Wolfradt & Pretz, 2001). Götz and Götz (1979) found that the correlation of neuroticism with creativity was negative in the sciences, but positive in the arts, and other researchers did not find a significant correlation between them (e.g., Eysenck & Furnham, 1993). Averill (1999) asserted that neuroticism implies an unusualness of response, but neurotic behavior is ineffective. Guilford (1971) insisted that, although divergent thinking and schizophrenic disorder may appear to be somewhat similar, it is hard to equate divergent thinking with psychotic thinking, and creative thinking is essentially rational (Schuldborg, 2001). Schuldborg's own study showed that among the correlation coefficients between subclinical psychopathological traits and the Richards Maximum of Peak Vocational and Avocational Creativity, there was one significant positive correlation ($r = .17, p < .05$), two significant negative correlations ($r = -.34, p < .01$ and $r = -.16, p < .05$), and the remaining four coefficients were not significant ($r = -.02, -.05, .08$, and $-.10$). In the present study, it is temporarily postulated that creativity has a positive correlation with emotional stability and a negative correlation with neuroticism. This study was to investigate the average effect sizes of the personality subscales of emotional stability,

openness, conscientiousness, extroversion, and agreeableness associating with creativity. These poles of the five dimensions of personality are generally supposed to be more socially acceptable than the opposite poles.

It would be helpful in the recruitment of creative personnel if an association of creativity with personal traits and/or with cognitive abilities could be identified.

CREATIVE PROCESS

Concerning the creative process, Basadur et al. (1982) proposed a model of three stages in the process of problem solving and postulated that ideation and evaluation might oscillate during the whole process. The three stages of the problem-solving process can further be extended to five stages: (a) defining the problem, (b) retrieving problem-related knowledge, (c) generating potential solutions, (d) generating criteria for evaluating appropriate solutions, and (d) selecting solution and implementing it. Defining the problem has the same meaning as problem construction described by Reiter-Palmon, Mumford, Boes, and Runco (1997). They defined problem construction as the restatement of the problem in as many different ways as possible before commencement of the solving of the problem. A result of Diakidoy and Constantinou's (2001) study showed that the number of valid responses that students could give to ill-defined physics problems could significantly predict the originality of the response in the explanation and prediction of problems. This indicates that domain-specific conceptual knowledge might be a prerequisite, although not necessarily a sufficient condition for domain-specific creative problem solving. The second stage, retrieving problem-related information, is parallel to information encoding as noted by Mumford, Baughman, Supinski, and Maher (1996). The third, generating potential solutions, is equivalent to category selection (Mumford, Supinski, Threlfall, & Baughman, 1996). The fourth, generating criteria for evaluating appropriate solutions, is similar to identifying evaluation criteria (Parnes & Treffinger, 1973), while the fifth, selecting a solution and implementing it, is the last stage of problem solving and may include a process of category combination, as noted by Mumford, Baughman, Maher, Costanza, and Supinski (1997), or reorganization of knowledge according to the complexity of the problem. This concept of regarding creativity as a reorganization of knowledge is similar to that of the associative theory of creative thinking, which defines the creative process as one of the forming of associative elements into new combinations that either meet specified requirements or are in some way useful (Mednick, 1962). The cycle of these five stages of the problem-solving process may recur if the selected solution does

not work satisfactorily. For the five stages of problem solving, prerequisite knowledge is decisive in the first and second stages, divergent thinking may play an important role in the third and fourth stages, and convergent thinking is a determinant in the fifth stage.

If one cannot solve the problem during the process of problem solving, but a break or rest is allowed, then a kind of incubation often occurs. The function of the incubation might be that it provides the individual, who has worked hard on a problem, an opportunity to reorganize the learned knowledge consciously or subconsciously. At present, no method has yet been found to manipulate the occurrence of desired outcomes during the process of incubation.

CREATIVE PRODUCT

Creative product, which includes ideas, solutions, performances, or products generated by the creative process, can be classified into two aspects: one is ideation with less evaluation (divergent-thinking oriented) and the other is ideation with more evaluation (convergent-thinking oriented). The Torrance (1996a, 1996b, 1996c) Tests of Creative Thinking (TTCT) are the most popular instruments used in the measurement of divergent thinking and cross-domain creativity. Problem solving belongs to the latter aspect, which needs factual and domain-relevant knowledge, special skills, and talents. Each aspect has its own measurable indicators. Whereas Guilford (1971) argued that divergent thinking abilities should not be expected to correlate very highly with other criteria of creative potential, Hinton (1970) found that among the 40 variables (37 measuring personality factors and three measuring ability factors) 20 had significant correlations with creative problem solving performance. Can it therefore be inferred that the average effect size of creativity with the use of more evaluation would be larger than that of creativity with the use of less evaluation?

Creative product was measured in terms of fluency, flexibility, elaboration, originality, quality, etc. Fluency is defined as "the ability to enumerate many ideas related to the problem," and flexibility as "the ability to shift readily among several kinds or classes of ideas and solutions" (Parnes & Treffinger, 1973, p. 8). Elaboration is needed in order to increase the acceptability and attraction of the solution or of the newly designed product. The quality of the solution in the solving of a problem was also included in the variable list because the quality of such a solution is conceptually and empirically different from the originality of a solution. Although the originality of a solution is creative, the quality of a solution is both creative and practical. Parnes and Treffinger (1973) also emphasized that genuine creativity must have an application in reality.

In addition to such general concepts of creativity (including domain-free verbal and figural creativity, as well as domain-specific creativity, such as creativity in art, science, etc.), another kind of creativity was explored: emotional creativity. Averill (1999) distinguished three facets of emotional creativity: preparedness, novelty, and effectiveness/authenticity and explored empirically their correlations with personality traits and cognitive abilities.

METHOD

Selection of Studies

A list of studies was assembled by conducting a computer search of The ProQuest Educational Journal, ProQuest Dissertation Consortium, and ERIC databases using *creativity and intelligence*, *creativity and personality*, and *creativity and cognitive ability* as the search terms. *The Creativity Research Journal* and *Journal of Creativity Behavior* were searched manually. Some articles were also traced from the references of selected studies. For studies where the creativity scores were not measured with a creativity test or with a judgment based on a creativity product, but where the researchers asked the participants to evaluate their own creativity or asked a teacher to evaluate the creativity of his or her students using the Likert scale: 5, 4, 3, 2, or 1 (where 5 = *very creative* and 1 = *very uncreative*) according to their own intuition; such studies were regarded as of poor quality and, therefore, not utilized. In addition, studies reporting solely significant correlation coefficients and omitting the nonsignificant correlation coefficients were excluded from the present study because to omit the nonsignificant correlation coefficients would inflate the mean effect sizes. However, studies using an inventory to measure attitude or personality by means of a Likert scale were acceptable and included in this study.

Coding Procedure

Two part-time assistants were trained to code the data. The coding and procedure were similar to that of an earlier meta-analysis (Ma, 2006). The data required to be coded were: article, definition of independent variable, definition of dependent variable, Ne, Nc, Me1, Mc1, SDe1, SDc1, Me2, Mc2, SDe2, SDc2, *t*-value, *F*-value, and *r*-value. The material to be keyed-in was marked in each of the located studies and then keyed-in by the research assistants. I then checked the data from each article against the content of the original article to ascertain whether or not there had been any typing errors and then corrected the errors immediately if any were found. The present author then wrote the conversion equations for Microsoft Excel. There was no calculation

TABLE 1
Classification of Variables Associated With Creativity

A. Variables of creative person

a. Attained variables

School performances: including Grade Point Average; score on standardized achievement test; Accomplishment checklist; Academic achievement based on leaving examination of high school; score on Iowa Tests of Basic Skills Reading (ITBS-R); core knowledge > noncore knowledge curriculum; story writing; oral narrative tasks; classroom performance rating of student teacher; second language acquisition; extracurricular activities; score on California Achievement Test; prior knowledge

Cognitive ability: including score on the following tests—IQ Tests; WISC-III Vocabulary; Raven's Cognitive Reasoning Test; The Metaphoric Comprehension; The Lunzer Test; The Wisconsin Card Sorting Test; The Minnesota Engineering Analogies Test; The Terman Concept Mastery Test; Lorge-Thorndike: Verbal and quantitative; The Scholastic Aptitude Test; The Graduate Management Admission Test; The Wechsler Intelligence Scale for Children; The Kuhlmann-Anderson Intelligence Test; The Pintner General Ability Test; The General Classification Test; The Arithmetic Reasoning Test; The Armed Force Qualifying Test; The Hidden Patterns Test; The Leveling-Sharpening House Test; The Object Sorting Test

Capacity for imagery: including visual imagery capacity and predisposition to fantasy

Humor (word-play; jokes)

Creative personality: including scores on Adjective Checklist (Creative Personality Scale); How Do You Think (measuring creative personality, interests, attitude, and self-perception); The Barron-Welsh Revised Art Scale (preference for complexity personality trait); personality in terms of a creative attitude; The Torrance Leisure Interest Checklist; The Golann Forced Choice Questionnaire; Panksepp's Affective Neuroscience Personality Scales; The Förändring och Stabilitet Test (eagerness to solve problems and to explore new things)

Emotional stability: including high scores of emotional stability and low scores of neuroticism (neuroticism has five subscores, i.e., anxiety, hostility, depression, self-consciousness, impulsiveness, and vulnerability); low anxiety

Extroversion: including high scores of extroversion (socially outgoing and adept) and low scores of introversion; seeking social support in coping with stressful situations (talking to someone to find out more about the situation); the Myers-Biggs Indicator of Personality Type (extrovert, intuitive, feeling, and perceiving)

Openness: including openness to experience as opposed to satisfaction with the familiar; nonconformity to school discipline; quest for religious orientation (having an open attitude toward issues of fundamental concern of existence); nonauthoritarianism (not adhering to received custom and authority); non-extrinsic religious orientation (not focusing on external rewards, not accepting the religion as a means to self-serving ends, such as security and social status); non-intrinsic religious orientation (not being true believers)

Agreeableness: including agreeableness (being compassionate, good-natured, & cooperative) as opposed to hostility (being proud, skeptical, and competitive); nonconfronting coping (attempts to alter the situation without the use of hostile risk-taking activity)

Conscientiousness: including conscientiousness (being well-organized, disciplined, & achievement-oriented) as opposed to indifference (being easygoing or detaching oneself emotionally from the situation); moral maturity; coping with a stressful situation not by distancing oneself from it, but by addressing it; accepting one's own part in the responsibility for a stressful situation

Cognitive styles: high scores of field-independence and low scores of field dependence

Willingness to take risks

Inclination for divergent thinking (including preferences for high ideation/low evaluation, high intuition/low reasoning, and high innovation/low adaptation, explorer > assimilator cognitive style; high tolerance of ambiguity)

Inclination for convergent thinking (including preferences for evaluation, reasoning, and adaptation, intolerance of ambiguity)

High scores of intrinsic motivation and low scores of extrinsic motivation (extrinsic motivation refers to hoping to acquire external reinforcements, such as a bonus; subjects were told that their tasks would be evaluated); constructive feedback (provision of information about the strength of students' collage); intrinsic religious motivation

Prestige of honors: including prestige of honors/awards; national academy membership; professional visibility

Leadership: including transformation leadership (the leader promotes innovation, motivation, & the expression of different viewpoints of group members); successful leadership on the Nursery School Leadership Observation Schedule

Nondelinquent

Psychological androgyny: having high scores on both femininity and masculinity

Self-efficacy: including self-efficacy (having a faith in one's own abilities); self-esteem; autonomy; self-determination; self-directing religious coping style (stressing one's own power to deal with problems without God's help); internal locus of control (the lower scores for Nowicki-Strickland (1971) Locus of Control Scale are associated with internal orientation, which indicates that life events are largely under internal or personal control instead of external control such as by powerful others or by chance); noncollaborative religious coping style (not viewing both God and the self as active contributors, working together to solve problems but self-directed); non-deferring religious coping style (not placing responsibility for problem solving on God); self-controlling (emphasizing control over one's own behavior and the situation); making plans to solve problems in coping with stressful situations (deliberate and analytic approaches to solving the problem); not choosing escape-avoidance in coping with stressful situations; high score on self-concept

Prior traumatic experience: including childhood and adolescent long-term benefits from overcoming hardships

Mysticism: including general mysticism (emphasizing transcendental experience and having a sense that all things are alive); religious interpretation (emphasizing the holiness or sacredness of an experience)

Affective sensibility including non-alexithymia (ability to identify and describe one's own emotional feelings) and empathy (ability to detect and describe the feelings of others)

Low scores on psychopathological traits: including low score on ego defense mechanisms which include 15 ego defense styles; low negative schizotypy including low scores on social anhedonia and low psychoticism (a high score on social anhedonia delineates social withdrawal and isolation & the inability to experience pleasure from social interaction; a high score on psychoticism measured with the Eysenck (1991) Personality Scales depicts vulnerability to psychosis; psychoticism includes subtraits of aggression, coldness, egocentricity, impersonalness, impulsivity, antisocialness, lack of empathy, creativity, & tough-mindedness)

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TABLE 1
Continued

<i>b. Ascribed variables</i>
Gender (female > male)
Birth order or number of siblings
B. Variables of creative process
Defining problem: including restatement of the problem as many different ways as possible before beginning to solve the problem; going deeper into questions; problem construction (the novel, ill-defined problem must be redefined or restructured); problem representation (identifying goals, procedures, information, & constraints of the problem); Westcott's (1962, 1968) Intuition Scale
Retrieving problem-related knowledge: Including information encoding or acquisition (searching & identifying or retrieving pertinent information, including relevant knowledge, facts, principles, rules, categories, concepts, etc.); technical expertise of drawing
Generating potential solutions: including category selection (selecting a set of categories or concepts to provide a basis of subsequent reorganization)
Generating evaluation criteria for selecting solutions
C. Situational variables
Class climate favorable for creativity: Including competitiveness between peers in achievement; competition > no competition; low friction among students; low cohesiveness between students; satisfaction with class climate; low difficulty of class work; teacher encourages creativity (including self-initiated learning, self-evaluation, manipulate materials, open discussion); instruction condition (heuristically demonstrating the same techniques in a more flexible form > algorithmically providing a rote step-by-step algorithm for building a sample structure); nominal group by brainstorming (exchange of written ideas or using computers) > interactive group brainstorming; anonymous > identified in electronic brainstorming
Quiet working circumstance: Including no alcohol-drinking; work setting with complexity of visual detail, natural view and natural material, less use of manufactured or composite surface materials, and with fewer cool colors used; no limits or informational limits during creative activities > controlling limits; free-play with salt dough before taking creativity test; systematic-relaxation exercises > unsystematic resting or music hearing; playfulness including physical spontaneity, social spontaneity, cognitive spontaneity, and manifest joy

of the percentage of inter-rater agreement as no judgments had to be made on the scope of the data to be keyed in.

When component subscores and total score were both available, the total score was ignored in order to avoid redundancy. If a variable was negatively correlated with creativity, the sign of its correlation was changed and the name of the variable was changed to a positive name in order to avoid canceling out the effect sizes of other variables, which had positive correlations with creativity. For example, neuroticism is not a positive personality trait but emotional stability is, if neuroticism was positively correlated with creativity, then the name of the variable *neuroticism* was changed to *emotional stability*, and the sign of the correlation coefficient was changed to be negative.

For the measurement of the effect size of age on creativity, a correlation between the age and creativity scores was preferred. However, if such a correlation was not available, and means, sample sizes, and SDs were presented instead, then the data of the lowest grade level or age were used as the data of the control group and the data of the other later grade level or age groups were used as the experimental group. For example, in Cheung, Lau, Chan, & Wu's (2004) study, Grade 1 was used as the control group for Grades 2 and 3, whereas Grade 4 was used as the control group for Grades 5 to 9, because Grades 1 to 3 were individually tested and Grades 4 to 9 were tested in a group.

Charles and Runco (2001) reported a correlation coefficient of 1.00. It was changed to .99 in the present study to let it be convertible to an effect size. If a composite score of creativity was derived from its elements, then the correlations between the composite and the

elements were not included in the calculation of effect size. The most difficult work in meta-analysis is the categorization of variables. Principally, discrete variables were aggregated to a broader category in accordance with the classifications as made by the authors referred to in the introductory section of this study. However, a combination and reorganization of the categories was carried out again and again as the author checked the coding of independent and dependent variables because of the occurrence of new variables.

Table 1 displays the classification of correlates of creativity and Table 2 lists the categorization of measures of creativity.

Calculation of Effect Size

Effect sizes were calculated from the means and SDs of the performance outcome of the experimental and control groups, or by converting the value of other statistical tests, such as r , t , or F . The formulas used in the calculation were adopted from Hedges and Olkin (1985), and Cooper and Hedges (1994):

$$\Delta = \frac{M_e - M_c}{SD_c}; \quad g = \frac{M_e - M_c}{\sqrt{\frac{(n_e - 1)SD_e^2 + (n_c - 1)SD_c^2}{n_e + n_c - 2}}};$$

$$g = \frac{t(n_e + n_c)}{\sqrt{n_e n_c (n_e + n_c - 2)}}; \quad g = \frac{2\sqrt{F}}{\sqrt{df}}; \quad (7)$$

$$g = \sqrt{\frac{4(N - 1)}{N}} * \frac{r}{\sqrt{1 - r^2}};$$

$$g = \frac{Me2 - Mc2}{SDc2} - \frac{Me1 - Mc1}{SDc1}; \quad ES = \sum_{i=1}^k n_i * es_i / \sum_{i=1}^k n_i.$$

TABLE 2
Variables of Creative Product (Categorization of Measures of Creativity)

A. Ideation with less evaluation

Nonverbal creativity: including figural battery of the Torrance Test of Creativity Thinking; Test for Creative Thinking—Drawing Production; Wallach and Kogan (1965) Creativity Test (nonverbal)

Nonverbal fluency: ability to produce a large number of ideas; motor fluency

Nonverbal flexibility: ability to produce a wide variety of ideas; motor flexibility

Nonverbal elaboration: ability to develop or embellish ideas and to produce many details

Nonverbal originality: ability to produce unusual ideas; unusualness; uniqueness

Verbal composite score of creativity: including Torrance (1996b) Test of Creativity Thinking (verbal); total score of two or more components of creativity; creativity test score without mentioning specific component; divergent thinking performance (generating phrases of words starting with given letters, titles for a short story, consequences of not having things, unusual uses for common items, groupings of items on a list, and completions of stem analogies); Wallach and Kogan Creativity Test (verbal); Wallach and Kogan's Uses and Pattern Meaning Test; Purdue Creativity Test; Numeric creativity; Minnesota Test of Creative Thinking (verbal)

Verbal fluency: ability to produce a large number of ideas

Verbal flexibility: ability to produce a wide variety of ideas

Verbal elaboration: ability to develop or embellish ideas and to produce many details

Verbal originality: ability to produce unusual ideas; unusualness; uniqueness

Abstractness of titles

Resistance to premature closure; overcoming fixation

B. Ideation with more evaluation (Problem solving)

Composite score of problem solution; convergent thinking performance (to perform task with analysis, linear reasoning, and evaluation of ideas); Advanced Vocabulary Test II—V-5 (a measure of verbal-comprehension problems); Paper Folding Test (a measure of spatial visualization problems); Inference Test—RL-3 (a measure of logical reasoning problems); creativity of the product; Wallach and Kogan Creativity Test (problem solving); Remote Association Test; creativity of publications; social problem solving (social creativity); coping abilities (the ability to adapt to environmental demands and to meet personal needs, measured with coping inventory); performance-based assessments (story-telling, collage-making, math problem); scientific creativity; statement of past creative activities; Creative Activities List; Vaughan (1971) Test of Musical Creativity Composite; painting products; divergent production in mathematics; "inventiveness" of the "Berlin Intelligence Structure Test"; New Scientific Uses Test; Scientific Incomplete Sentences Test; Scientific Word Association Test; Real-World Divergent Thinking Test; portfolio of photographs rated by professionals

Fluency of solution (number of nonredundant solutions)

Flexibility of solution (number of categorical shifts made in solutions)

Elaboration of solution (details included in each solution; attractiveness of the product; interest of the product)

Originality of solution (the novelty of the solution); evaluation of originality

Quality of solution: including appropriateness, effectiveness or workability of solution; likeability; technical quality of solution (product); expressivity, repleteness, and composition of drawing

C. Emotional creativity

Emotional creativity (total score as measured by Emotional Creativity Inventory)

Preparedness: understanding and learning from one's own and other's emotions

Novelty: ability to experience unusual emotions

Effectiveness and authenticity: The skill to express emotions adroitly and honestly leading to potential benefit to the individual or group

Preparedness: Understanding and learning from one's own and other's emotions

where ES is the weighted grand mean effect size (a less biased estimate than unweighted) of the 111 located studies, k is the number of studies, and n_i is the averaged sample size of i th study (because some studies had different sample sizes within a given study).

RESULTS

Altogether, 2,013 effect sizes from 112 studies were analyzed. Among the 2,013 effect sizes, 1,554 were converted to effect sizes from correlation coefficients, 27 from F -values, 33 from t -values, 17 from pre- and post-test comparisons of means, and 379 from a posttest comparison of means. Three effect sizes were directly presented by the original author.

After averaging the effect sizes of each study to represent the mean effect size of each study, the mean

of the total 112 effect sizes was 0.68 with a SD of 0.69. The lag 1 autocorrelation of the residuals, created by subtracting each effect size from the grand mean, of the 112 effect sizes was .07 with a standard error of .09, $p > .05$. This result indicates that the assumption of the independent distribution of the residuals was not violated and parametric statistics could be used to analyze the data. The result of a one-sample t -test, $t(111) = 10.46$, $p < .0001$, revealed that the grand mean effect size of 0.68 was significantly different from zero.

The mean of the total 2,013 effect sizes was 0.73 with a SD of 1.16. The lag 1 autocorrelation of the residuals of the 2,013 effect sizes was .380 with a standard error of .02. Such result was significantly different from zero and means that the distribution of the residuals was not independent and violated an assumption of parametric statistics. Therefore, it was

more suitable to use nonparametric statistics for the further analysis of these data.

According to Cohen's (1977) guidelines, an effect size of approximately 0.2 is small, 0.5 is medium, and 0.8 is large. The grand means of 0.73 for the 2,013 effect sizes and 0.68 from the 112 were between a medium and large effect size.

Specific Analyses

Three clusters of data will be separately analyzed and presented because of theoretical or psychometric differences with other studies:

The mean effect sizes of the psychopathological traits. Fantasy is central to creativity, it is inferred that people with psychopathological fantasies are more creative (Domino et al., 2002a). Thirty-six effect sizes of psychopathological traits were analyzed separately because they were based on psychoanalytical or psychiatric theory claiming an association between deviant personality traits and creativity. The results showed that a person with a higher score on psychopathological traits had higher scores on divergent creativity than a person with a lower score on psychopathological traits with a mean effect size of 0.5, but that the reverse was true for creativity in solving problems (the mean effect size was -0.14). In the calculation of the grand mean of the 2,013 effect sizes, the term *high psychopathological traits* was changed to *low psychopathological traits* and the sign of the effect sizes was reversed.

The predictive power of creativity scores (verbal) on later school performance. Fifty-two of the effect sizes from two studies (Howieson, 1981; Torrance, 1972) investigated the predictive validity of creativity scores on later creative achievement. Torrance (1972) made a review of the predictive validity of the TTCT on creative achievements 5–12 years later. Howieson investigated the predictability of the 1965 TTCT creativity scores in regard to later achievements over time, which were reported in 1975. The results revealed a medium mean effect size of 0.56.

The mean effect size of a problem finding oriented working field on the ideation-evaluation ratio. Basadur (1995) classified organizational members into three fields of endeavor: (a) problem finding, (b) problem solving, and (c) solution implementation and investigated their effects on the ideation-evaluation ratio. A result showed that the mean effect size from three effect sizes was 0.89 indicating that a problem finding-oriented field, such as research, emphasized more on ideation than on evaluation and that the reverse was true for a solution implementation field, such as manufacturing, and that a

problem-solving-oriented field, such as marketing, fell in-between.

Mean Effect Sizes on the Measures of Creativity

With the exclusion of Basadur (1995)'s study, the remaining 111 studies producing 1,926 effect sizes constituted as the main data body and were analyzed further. When the averaged effect size of each study was weighted with the average sample size of that study, the weighted grand mean effect size of the 111 studies was 0.72, an effect size between medium and large.

Table 3 displays the mean effect sizes of personal and environmental variables associated with four categories of measures of creativity. The measures of creativity were treated here as dependent variables.

Levene statistics showed that the variances of the residuals were not homogeneous, $F(3, 1922) = 12.21$, $p < .001$. Using the Kruskal-Wallis one-way analysis of variance by ranks (K-W ANOVA), the difference between the mean ranks of the four categories of creativity was significant, $\chi^2(3, N = 1926) = 66.39$, $p < .001$. Post hoc comparisons by means of the Mann-Whitney U test demonstrated that the mean ranks of the effect sizes on problem solving creativity and verbal creativity were significantly larger than those of emotional creativity and nonverbal creativity.

Mean Effect Sizes of Variables Associated with Creativity

Table 4 reveals that variables, of which the mean effect sizes exceeded 0.5 were, in ranked order, prestige of honors/awards, working circumstances favorable for creativity, defining problem, retrieving knowledge, class climate favorable for creativity, openness, mysticism, affective sensibility, and scores in creative personality tests. Cognitive abilities such as IQ and school performance had only a small mean effect size (about 0.3).

The mean effect sizes of personality. The creative personality tests showed a medium mean effect size (0.61), which indicates a higher predicative power for creativity than for any other component of the

TABLE 3
Mean Effect Sizes on the Four Categories of Creativity

Categories of Creativity	k	Mean rank	Mean	SD
Nonverbal creativity	161	713	0.45	0.87
Verbal creativity	847	1004	0.79	1.11
Problem solving	787	1011	0.86	1.29
Emotional creativity	131	728	0.34	0.43
Total	1926		0.76	1.15

TABLE 4
Mean Effect Sizes of Variables Associated With Creativity

<i>Variables</i>	<i>k</i>	<i>M</i>	<i>SD</i>
A. Variables of creative person			
<i>a. Attained variables</i>			
School performances	166	0.36	0.44
Cognitive abilities	206	0.31	0.36
Imaginary capacities	9	0.29	0.29
Humor	2	0.48	0.45
Creative personality	38	0.61	0.66
Emotional stability	28	0.26	0.33
Extroversion	24	0.30	0.32
Openness	24	0.71	0.70
Agreeableness	13	0.15	0.21
Conscientiousness	19	0.23	0.33
Cognitive style	4	0.42	0.28
Willingness to take risks	6	0.13	0.64
Inclination for divergent thinking	8	0.43	0.25
Inclination for convergent thinking	7	0.20	0.22
Intrinsic motivation	33	0.30	0.50
Prestige of honors	3	1.39	0.18
Leadership	16	0.56	0.60
Non-delinquent	7	0.49	0.19
Psychological androgyny	10	0.40	0.36
Self-efficacy	46	0.22	0.32
Prior traumatic experiences	24	0.45	0.39
Mysticism	6	0.67	0.31
Affective sensibility	10	0.65	0.83
<i>b. Ascribed variables</i>			
Gender	104	0.14	0.43
Birth order	55	0.31	0.47
Age	154	0.34	0.47
B. Variables of creative process			
(problem solving process)			
Defining problem	40	0.93	0.83
Retrieving knowledge	8	0.86	0.50
Generating solutions	10	0.49	0.27
Generating evaluation criteria	5	0.41	0.30
for selecting A solution			
Selecting solutions	23	0.43	0.34
C. Environmental variables			
Class climate favorable for creativity	26	0.71	0.85
Working circumstances favorable	31	1.13	1.19
for creativity			
Total	1165	0.39	0.54

Note. K = Number of effect size. M = Mean.

five-factor personality traits, the so-called Big Five, with the exception of openness (0.71). When creative personality and the five-factor personality traits were put together, the six measurement variables showed a mean effect size of 0.43 with a SD of 0.54. Levene statistics showed that the variances of the residuals were not homogeneous, $F(5, 140) = 7.13, p < .001$. Using the K-W ANOVA, the difference between the mean ranks of the six factors of personality traits was significant, $\chi^2(5, N = 146) = 16.59, p = .005$. Post hoc comparisons by means of the Mann-Whitney U test demonstrated that the mean ranks of the effect sizes of openness and creative personality tests were significantly larger than that of extroversion, emotional stability, agreeableness, and conscientiousness.

The mean effect size of components of problem solving procedures on creativity. Most of the mean effect sizes of the problem-solving procedures on the measures of problem solving surpassed the medium of Cohen's (1977) guidelines (Table 5).

Such variables, of which the mean effect sizes are larger 0.9, were, in ranked order, the effect of problem finding on the fluency of the solution, and composite score of problem solution; the effect of retrieving knowledge on originality, and the quality of the solution. That many entries in Table 5 have missing value implies that much remains to be explored in this area. Especially, the association between the problem-solving procedures with the elaboration of solution were totally not investigated.

The correlation coefficients were classified according to the four categories of Table 3 into two groups: the intracategory and intercategory group, the mean correlation of the intracategory group was .46 ($k = 576$), with a 95% confidence interval of .44-.48, and that of the intercategory group was .31 ($k = 177$) with a 95% confidence interval of .27-.35. That confidence intervals of 95% had no overlapping indicates that the mean of the

TABLE 5
The Mean Effect Size of Components of Problem-Solving Procedures on Problem-Solving Creativity

<i>Problem-Solving Procedure</i>	<i>Products of Problem Solving</i>					<i>Total</i>
	<i>B0</i>	<i>B1</i>	<i>B2</i>	<i>B3</i>	<i>B4</i>	
A1	1.09 (.100/20)	1.56 (.84/4)	—	0.67 (.33/9)	0.63 (.15/5)	0.93 (.83/40)
A2	—	—	—	0.98 (.057/5)	0.82 (.034/2)	0.86 (.050/8)
A3	—	0.54 (.000/1)	0.00 (.000/1)	0.58 (.023/3)	0.57 (.028/4)	0.49 (.027/10)
A4	—	—	0.34 (.022/2)	0.20 (.000/1)	0.6 (.042/2)	0.41 (.030/5)
A5	—	—	0.05 (.008/4)	0.43 (.035/8)	0.43 (.034/10)	0.56 (.031/23)
Total	1.09 (.100/20)	1.36 (.085/5)	0.12 (.018/7)	0.63 (.041/26)	0.60 (.027/23)	0.71 (.066/86)

Note. A1 = Defining problem. A2 = Retrieving knowledge. A3 = Generating solutions. A4 = Generating evaluation criteria for selecting solution. A5 = Selecting appropriate solution. B0 = Composite score of the solution to the problem. B1 = Fluency of the solution. B2 = Flexibility of the solution. B3 = Originality of the solution. B4 = Quality of the solution.

Data in the parentheses are SD/number of effect sizes. Missing values (—) indicate that these areas have been not investigated thus far.

intracategory correlations was significantly larger than those of the intercategory correlations.

DISCUSSION

The main purpose of this study was to use meta-analysis to investigate the mean effect size of relevant variables associated with creativity without training. The mean of the total 2013 effect sizes from 112 studies was 0.73, an effect size between medium and large. Important findings will be discussed in this section.

Problem Solving Procedures

Problem-solving creativity may be expected to be a promising field of research in the future. Creativity is still an art, because the mechanism of creative thinking is not well known. When the mechanism governing creative problem solving is identifiable, then creativity will become a science and be taught in an effective manner. Most of the mean effect sizes of the problem-solving procedures on the measures of problem solving in the present study exceeded the medium of Cohen's (1977) guidelines. Among the five stages of the problem-solving process, problem finding and retrieving knowledge showed large mean effect sizes, with 0.93 and 0.86, respectively. These results seem to support the axiom that defining the problem is the half of the success in solving the problem. Also, *retrieving knowledge* showed a large mean effect size, and this result seems to suggest that knowledge is a prerequisite, although not sufficient condition, for problem solving (Mumford, Supinski, Baughman, Costanza, & Threlfall, 1997). The cells of missing value in Table 5 imply that problem solving is a field deserving of further attention in future research.

Prestige of Honors or Academic Awards

Prestige of honors or academic awards showed the highest rank of effect size (mean effect size was 1.39). The higher the prestige of the honors or awards a scientist has received or the higher the academic membership or professional visibility a scientist has, the higher his or her works would be rated by peer scientists. As to reasons why a prolific eminent scientist can produce works of high quality, it is possible that during the production of his or her publications, he or she becomes more open to the comments and suggestions of peer reviewers that would lead to improvements in his or her strictness towards research attitude, writing skills, logical thinking, and creative or innovative thinking. However, this reasoning can only be regarded as a hypothesis awaiting future testing.

Working Environments

Working circumstances favoring creativity are quiet, alcohol-free, natural, relaxed, and unrestrained. A more natural environment, such as a natural view from a window, with natural materials can contribute to the conception of freedom (McCoy & Evans, 2002). It is possible that a quiet and natural environment may facilitate the process of the reorganization of knowledge, thoughts, cues, facts, information, and/or skills, and lead to creative performance.

Class Climate

A class climate with high competition but low friction, with the teacher encouraging creative and reflexive thought, is favorable for creativity. Creativity scores were found to be higher when pupils were provided more opportunities to manipulate materials, to participate in open discussions, to participate in self-evaluation, and to engage in self-initiated learning (Lopez, Esquivel, & Houtz, 1993). This class climate may enhance the pupils' attitude of openness to new experiences.

Openness to New Experiences

An open personality has a medium effect size on creativity. It implies that being open to new experiences, as opposed to satisfaction with the familiar, having an open attitude toward issues, and not adhering to received custom and authority are favorable for creativity. These findings confirm the conjecture formulated by Feist (1998) that people with more openness to new experiences would have a wider reservoir of thoughts and problem-solving strategies available to be combined for creative thinking.

Mysticism

Mysticism is a tendency to interpret an unusual experience as a general or religious mystery. Averill's (1999) study showed that mystic-like experiences were associated with emotional creativity.

Affective Sensibility

Affective sensibility is the ability to identify and describe one's own emotional feelings to others (nonalexithymia) and the ability to detect and describe the feelings of others (empathy). Alexithymia was inversely related to emotional creativity (Averill, 1999) and empathy correlated positively with creativity (Carlozzi, Bull, Eells, & Hurlburt, 1995). These findings imply that creative people are more inclined to make open-minded

communication of their own feelings to others and that their perceptions of others' affective messages may be more unprejudiced.

Creative Personality Scales

Creative personality scales are instruments using adjectives to describe a person's creativity attributes, such as the Adjective Check List. There were high correlations between different creative personality scales and these different scales had also high correlations with creativity (Domino, 1994). The scores on creative personality scales are to some extent predicative for one's creativity.

Leadership

Leadership was found to be positively correlated with creativity (e.g., Fu, Canaday, & Fu, 1982; Howieson, 1981). The creativity of group members working under higher levels of transformational leadership was higher than that of those working under lower levels (Jung, 2001; Sosik, Kahai, & Avolio, 1998). This result confirms Amabile's (1998) hypothesis applying to an organization that a transformational leader in an innovation enhancing group can also foster creativity among its members by encouraging them to try out innovative approaches without the fear of punishment for failure.

Definition of Creativity

Finally, as Runco, Nemiro, and Walberg (1998, p. 2) pointed out: "Of the various definitions of creativity, which is the most useful? Which is the most highly respected?" According to the evidence derived from the present study, creativity can be defined as "the ability to reorganize the available knowledge, information, cues, facts and/or skills in a person's reservoir to generate new ideas or useful solutions." Creativity can be cultivated, partly by an individual's orientation and partly by institutional policies. If one holds an attitude of openness to new experiences and new information including knowledge, skills, and so forth; builds up an abundant reservoir of ideas; and has a willingness to reorganize available information to generate ideas or solutions that have not been generated before; remembers to define the problem thoroughly before beginning to solve it; one may gradually become a creative person. Likewise, institutions that encourage these habits and conditions can cultivate creativity.

Limitations of the present study must be mentioned: (a) About 77% of the effect sizes were obtained from correlation coefficients. However, a few effect sizes came from comparison groups (but not from experimental

studies which examined the effect of training). Therefore, the restriction of the range of the groups may lead to an underestimate of the true effect size; (b) the quality of the located studies was not controlled in this study (e.g., publication in a peer-reviewed source, use of controls, citation rate). A failure to take into account differences in the quality of work across studies could lead to inaccurate estimates of effect size; (c) the number of studies included in the present meta-analysis might not be exhaustive and new articles of relevance to the subject appear in the journals daily. The purpose of this study was to gather and consolidate current knowledge in the field of creativity and to elicit topics for further research as much remains to be explored, for example, in the area of the problem solving process.

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