

# THE SCIENTIFIC INVESTIGATION OF CREATIVITY: WHAT SHOULD WE STUDY?

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The concept of creativity has long been a source of intrigue for scientists. Where is it that novel ideas come from? The very mention of the words "creativity" and "science" in the same sentence, however, often evokes a wide variety of emotional, often negative, reactions. Those who maintain that creativity is wholly mystical voice strong objection to any empirical investigation into what they maintain is an unknowable process. Such protests to scientific inquiry are exemplified in the poetry of Keats:

Do not all charms fly  
At the mere touch of cold philosophy?  
There was an awful rainbow once in Heaven:  
We know her woof, her textures, she is given  
In the dull catalogue of common things.  
Philosophy will clip an angel's wings.

This view, which is widely held by many modern philosophers and social scientists as well, raises a critical question: Is scientific inquiry into the creative process worthwhile? Our positions, Keats to the contrary, is that this question must be answered in the affirmative.

By way of illustration, it is instructive to recall the story of Aristotle and the two stones. It was Aristotle who asserted that a large stone will fall faster than a small stone. What is interesting about this story is not only that Aristotle's intuition or personal knowledge was wrong but also that his claim was not disproved for nearly 2,000 years. It was not until the 16th century that Galileo decided to test Aristotle's claim by dropping two stones, a heavy one and a light one, from the top of the Leaning Tower of Pisa. Of course, it is well-known that objects in free-fall fall at the same rate of acceleration, but the point of this illustration is that in the absence of an empirical test, intuition can remain in error.

It is our contention that intuition or personal knowledge is an important component of any inquiry process.<sup>1</sup> Perhaps it was personal knowledge or a "good hunch" which led Galileo to drop his stones from the Tower. Personal knowledge about natural laws, just as personal knowledge about the creative process, is inherently limited since it has no way to validate itself. Only through scientific inquiry and experimentation can our knowledge, hunches, and hypotheses about creativity be validated.

## What To Study?

Before creativity can be studied scientifically, it must be defined. Scientific investigation demands that the phenomenon under study be operationalized. To study creativity, we must be able to specify what we mean when we say that an individual is behaving or thinking in a creative manner.

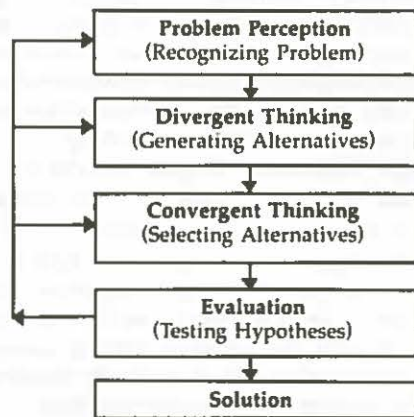
The study of creativity has considerable historical precedence and over two decades of research can provide suggestions as to what others have viewed as creative production. Most theoretical discussions on the topic<sup>2</sup> have viewed creativity as an interaction of two different thinking abilities—divergent production (the generation of an array of possibilities) and convergent production (the selection of optimal solutions from this array of possibilities). The strategy adopted by most researchers, however, has been to view divergent production as a necessary prerequisite to creativity and, as a result, the study of creativity has become nearly synonymous with the study of divergent thinking.<sup>3</sup> This emphasis has been pervasive both in creativity training techniques<sup>4</sup> and in the assessment of creative potential.<sup>5</sup>

By far the most commonly reported measures of creativity are the *Torrance Tests of Creative Thinking*<sup>6</sup> which assess divergent production in both verbal and figural modes. The four scores derived from these tests are good examples of how the study of creativity has been operationalized. The Fluency score reflects the quantity of answers produced. Flexibility refers to the number of categories of responses. Originality is based on the statistical infrequency of an answer vis a vis those of the national reference group. Elaboration describes the level of detail involved in a given answer. High creativity scores are given to protocols with many detailed answers in a variety of categories which are not commonly given by others responding to the test. Note that the utility, feasibility, or "goodness" of an answer is not reflected in these scores. An "original" (statistically infrequent) response may be creative, or it may be merely bizarre.

For this and other reasons, several researchers have argued that most scores in creativity studies have little to do with an individual's ability to creatively resolve a problem situation.<sup>7</sup> All too often prolific divergent production has been assumed to indicate concomitant, efficient convergent

production. Few studies have incorporated indices of convergent processes, much less a direct examination of convergent production. The most notable exceptions have been studies of problemsolving.<sup>8</sup> Several researchers such as Putz-Oserloh<sup>9</sup> have produced useful schematics of creative problemsolving. These schematics often involve some variation of the following scheme: recognition of a problem, which triggers divergent production of an array of potential solutions; followed by convergent production, which then allows prioritization of this array and selection of the most promising alternative; and, finally, a test of this alternative either leads to an acceptable solution or acts as a stimulus for further divergent production, reprioritization, testing, etc. Figure 1 summarizes the essential points of creative problemsolving models proposed by several researchers.

**Figure 1**  
**General Model of Creative Problemsolving**



To the extent such a scheme represents an individual's response to a novel situation, the study of creative problemsolving becomes synonymous with the study of creativity. Rather than assuming the necessity and sufficiency of divergent processes in the study of creativity, creative problemsolving models better represent the sense of what most of us mean when we refer to something as creative or to someone as a creative thinker.

For several years, we have been pursuing a line of research which seeks not only to elucidate procedures to improve creative problemsolving but also to understand the contributions of various cognitive processes to creative problemsolving. Rather than developing an omnibus (and of necessity, non-differentiated) training procedure for creative problemsolving, our strategy has been to investigate, first, the relationship of several cognitive processes to creativity. We felt that a better understanding of these relationships would

afford an additional approach to training. Our work on these interrelationships and the training procedures we have developed as a result are described and discussed in the following sections.

## Experiment I

### Problemsolving and Analytic and Divergent Processes

Problemsolving, or creative problemsolving, requires both global (inductive) and analytic (deductive) styles of thinking. These thinking styles can be assessed in several ways, in addition to the divergent vs. convergent measures discussed above. It is suggested that a better understanding of creative processes may be gained by examining how they are related to broad, theoretical constructs, such as cognitive style.<sup>10</sup> One measure of particular utility is the Embedded Figures Test (EFT) developed by Witkin<sup>11</sup> at the Educational Testing Service in Princeton, New Jersey. In performing an EFT task, an individual attempts to locate a previously seen figure which is hidden or embedded within a more complex visual field. The ability to consistently locate these hidden figures is linked to abilities in "breaking up" a field into meaningful components, i.e., analytic thinking style. By elucidating the relationship between creative problemsolving abilities and field-independent/field-dependent cognitive styles, we may generate a fresh and useful perspective for explaining creative processes. Field dependence-independence<sup>12</sup> has been a well-studied topic in cognitive-style research. This dimension has been linked to a host of abilities including interpersonal competencies, skills in cognitive restructuring and intellectual functioning. It is important to note, however, that field dependence-independence does not connote "good" or "bad" attributes, but are reflective of different psychological approaches to problems whose adaptiveness depends on the situational context.<sup>13</sup>

We hypothesized that significant relationships between problemsolving, divergent thinking, and field dependence-independence would enhance our knowledge of the general process of creative problemsolving. For example, one might propose that the creative solution to many problems would require an individual to break up a complex array of stimuli so that the parts may be recombined in a new light. Contrary to this position, Rebecca, et al,<sup>14</sup> have suggested that field-dependent individuals may, in fact, score better on creativity tasks due to their greater responsiveness to social (and instructional) stimuli. While there is some empirical support for this latter notion, the relationship between field dependence-independence and creative problemsolving remains an open question and forms the basis for the present investigation.

### Method

#### Subjects

Eighty-three second-graders, 42 females and 41 males, from

the Center for Development of Early Education of The Kamehameha Schools in Honolulu served as subjects.

**Materials**

The measures included the Children's Embedded Figures Test (CEFT), the Torrance Test of Creative Thinking (TTCT), and the Purdue Elementary Problem Solving Inventory (PEPSI). These tests are described below.

**CEFT.** This test is designed to tap field dependence-independence.<sup>15</sup> The child is asked to locate a small figure which is hidden in a more complex field.

**TTCT.** This test consists of verbal and figural subtests which are designed to measure creative abilities.<sup>16</sup> In this study, the results of two verbal and one figural subtests are reported (Unusual Uses, Consequences, and Picture Completion).

**PEPSI.** This measure is designed to assess the creative and social problemsolving skills of elementary school children.<sup>17</sup> Children are presented slides depicting socially relevant problems and are asked to choose appropriate solutions and alternatives from a test booklet.

**Procedures**

Three staff members from the Center served as experimenters (two females and one male). The PEPSI was administered in a large staffroom to groups of 10 to 12 students. A color monitor with VCR was used in presenting all test questions, i.e., slides and audio had been recorded on videotape. The TTCT was administered at a different time on a class-by-class basis (25 students per session). The CEFT was administered individually by the three experimenters in one of two small testing booths.

**Results and Discussion**

A table of intercorrelations of the relevant measures for all subjects is presented in Table I; for females in Table II, and for males in Table III. As predicted, creative problemsolving (PEPSI scores) was positively correlated with field-independence (CEFT scores). The overall correlation (males and females) was .39 ( $p < .01$ ). For males only, this correlation was .62 ( $p < .01$ ), while the PEPSI-CEFT correlation for females only was .14 (n.s.). The TTCT subscore of Uses-Fluency correlated  $-.18$  ( $p < .05$ ) with PEPSI scores (males and females) and the TTCT subscore of Picture-Completion-Originality correlated  $-.37$  ( $p < .05$ ) with PEPSI scores for females.

**Table I**  
**Correlations For All Subjects**  
(N = 83)

	CEFT	PEPSI	Unusual Uses Fluency	Picture Completion Originality	Consequences Flexibility
CEFT	1.00				
PEPSI	.39**	1.00			
Unusual Uses Fluency	-.14	-.18*	1.00		
Picture Completion Originality	.12	-.14	.22*	1.00	
Consequences Flexibility	.11	-.12	.15	.20*	1.00

\*  $p < .05$   
\*\*  $p < .01$

**Table II**  
**Correlations For Female Subjects**  
(N = 42)

	CEFT	PEPSI	Unusual Uses Fluency	Picture Completion Originality	Consequences Flexibility
CEFT	1.00				
PEPSI	.13	1.00			
Unusual Uses Fluency	-.02	-.14	1.00		
Picture Completion Originality	.14	-.37	.31*	1.00	
Consequences Flexibility	.19	-.24	.18	.08	1.00

\*  $p < .05$

**Table III**  
**Correlations For Male Subjects**  
(N = 41)

	CEFT	PEPSI	Unusual Uses Fluency	Picture Completion Originality	Consequences Flexibility
CEFT	1.00				
PEPSI	.62**	1.00			
Unusual Uses Fluency	-.27	-.22	1.00		
Picture Completion Originality	.11	.07	.14	1.00	
Consequences Flexibility	.06	-.03	.13	.30*	1.00

\*  $p < .05$   
\*\*  $p < .01$

The data provide moderate support for the proposed relationship between field-independence and creative problem-solving. This support stems from the .64 ( $p < .01$ ) and .39 ( $p < .01$ ) PEPSI-CEFT correlations for males, females, and males and females combined, respectively.

At this point, it should be noted that the PEPSI test, compared to the TTCT, is more problemsolving-oriented and contains many measures of convergent processes. The TTCT is generally an open-ended test which mainly taps divergent production. Thus, we may say that the scores on the PEPSI reflected more than the "goodness" of a solution, involving, as it did, comparison to a more rigid "standard."

In this light, the data suggest that field independence may be linked to the creative solution of problems involving a standard. The fact that Uses-Fluency (overall) correlated  $-.18$  ( $p < .05$ ) with PEPSI scores suggests that divergent production may, in fact, work against the successful creative solution of problems in certain circumstances. This means that, contrary to the widely held opinions of creativity researchers, the ability to generate many possibilities for problems lacking a standard may not be sufficient criteria for study of the creative process.

Finally, the suggestions of Rebecca, et al.,<sup>18</sup> that field-dependent style may be linked to high creativity scores on the basis of greater social and instructional responsivity, is not supported in this study. We are encouraged by this preliminary research and feel future research should focus on how other aspects of cognitive styles, e.g., impulsivity-reflectivity, locus of control, are related to the creative problemsolving process.

## Experiment II

### Can We Train Analytic Thinkers?

To many, the notion of training individuals to think in more creative or analytic ways is strange. Traditionally, social scientists have viewed such abilities as trait-like entities which are "static" or, simply, "part of" a person. There is a wealth of literature, however, that warns that trait-type interactions often have limited utility and validity.<sup>19</sup> The past 10 years of research at the Center for Development of Early Education on reading and cognitive abilities in Hawaiian children has demonstrated that the leaps and bounds that children of the Kamehameha Early Education Program (KEEP) experienced are certainly not in keeping with previously held notions of the "character" of Hawaiian children.<sup>20</sup>

Many studies have demonstrated that creativity, at least in the narrow sense of divergent thinking, can be trained.<sup>21</sup> Typically, however, findings have indicated a lack of generalizability of training effects beyond the training task. One of our initial hypotheses was that a training technique which trained the use of generalizable strategies<sup>22</sup> should improve transfer of training from the divergent thinking task used in training. Cognitive modeling training involving divergent

thinking strategies (having subjects view a model who expressly verbalizes strategies applicable to successful task performance) has proved quite effective with both college undergraduates and second-graders.<sup>23</sup> Generalization to other divergent-thinking tasks occurred only with the undergraduates, however. Even though these results supported the value of cognitive modeling and strategy training for training generalizable skills, their implication for creativity training in its broadest sense is limited since the focus was solely on divergent production. An investigation which more adequately addressed other aspects of creative production was obviously needed, and our results of research with the EFT suggested that training in analytic thinking would be one such aspect or component of creativity to explore.

## Method

### Subject

The subjects in this study were 71 undergraduate students enrolled in psychology classes at the University of Hawaii at Manoa.

### Materials

In order to examine our notions that analytic thinking is subject to training, several modeling videotapes were produced which were designed to teach strategies relevant to analytic thinking. The two tapes were: (1) Cognitive Modeling Videotape, a 10-minute tape in which the model performed four different EFT analytic-type tasks and simultaneously discussed eight strategies relevant to EFT performance, and (2) Exemplar Modeling Videotape, a 10-minute videotape identical to the cognitive modeling tape with the exception that the audio was turned off. The Embedded Figures Test served as the principal assessment measure.

### Procedure

Subjects were randomly assigned one of three conditions: (1) exposure to cognitive modeling videotape, (2) exposure to exemplar modeling videotape, and (3) no-treatment control. Following the training phase, all subjects completed several measures related to analytic and cognitive abilities. In this article, the effects of treatment on one of the dependent measures—the Embedded Figures Test—will be reported. A complete examination of all measures in this study has been reported elsewhere.<sup>24</sup>

## Results and Discussion

The one-way ANOVA for the Embedded Figures Test for the three groups—cognitive modeling, exemplar modeling, and control—resulted in  $F(2,68) = 12.21$  with  $p < .01$ . The protected *t* test (2-tailed) revealed that the cognitive group outperformed the control group ( $t = 4.93$  with  $p < .01$ ), and the exemplar group outperformed the control group ( $t = 2.93$  with  $p < .01$ ). The cognitive group also outperformed the exemplar group ( $t = 2.12$  with  $p < .05$ ).



The results of this study suggest that analytic thinking styles, at least those tapped by the Embedded Figures Test, may be trainable. As in our study with divergent thinking, the cognitive modeling procedures, in which relevant strategy cues were presented along with behavioral examples, were especially effective in modifying cognitive performance. Elements of cognitive functioning are certainly malleable and able to be influenced by relatively brief interventions. Even elements thought to represent relatively enduring cognitive styles can be altered.

The present data suggest that cognitive modeling or explicitly teaching strategies of task performance provides generally superior results to expecting subjects to extract the necessary elements of performance from modeled behavior only. Further, there is some indication that explicit training of strategies produces generalization to other tasks and other modes of response from that used in training. This occurs, however, only when the strategies taught are applicable to the generalization task. Ensuring that this is the case is no easy matter, and more work remains to be done to define generalizable strategies for problemsolving.

### Conclusion

The preliminary data from these two experiments are exciting both in that they support the overall experimental strate-

gy we have adopted to study creativity and in that they suggest that creative abilities in addition to divergent production may be considerably more malleable than previously thought. The results also underscore the need for studying more than divergent production in understanding creative problemsolving. The assumption that divergent production is a necessary prerequisite to problemsolving and that efficient convergent production will automatically follow along has been shown not to be tenable. The full spectrum of creative problemsolving must be studied, including the interplay of divergent and convergent processes.

The experimental strategy we have adopted has provided us with an approach to studying aspects of creative problemsolving and left us with a number of hypotheses for future investigation.

Our study of the relationship of field dependence-independence to problemsolving has also led to the development of cognitive training procedures for analytic thinking. These procedures have proved to be quite compatible with those we have developed for training divergent production, and when combined with procedures for training divergent production, may produce a highly effective package for training creative problemsolving. Future research will focus on applying our present results to young children and incorporating our further findings on cognitive style into procedure for enhancing the training of creative problemsolving.



## Footnotes

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<sup>14</sup>Rebecca, et al., *op. cit.*

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