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The Figural Problem Solving and Problem Finding of Professional and Semiprofessional Artists and Nonartists

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ABSTRACT: The processes of finding a solution to a stated problem and those employed in formulating a problem prior to determining a solution strategy are implied by the behaviors observed in the manipulation of figural symbol systems. Sixty adult participants agreed to be videotaped while given two measures of spatial visualization, a figural problem-solving activity, and two games which required defining a problem prior to producing a result. When groups, defined by their experience in producing ideas in art, were compared, traditional quantitative measures of performance yielded few significant differences. However, multivariate analyses of the observed qualitative variables resulted in significant differences. Theoretical and educational implications are discussed.

Students with demonstrated creative ability, especially in the arts, often do not perform well on psychometric measures of intellectual ability (Kay, 1982). On the other hand, many educators find that students identified as potentially gifted through scores on an IQ or achievement test do well when asked to give correct answers, but have noticeable difficulty with the production of ideas. Basic skills of divergent thinking required by many creative problem-solving activities offer an unexpected challenge to many students identified as gifted through psychometric measures. As a result, many educators are convinced that creative ability is unrelated to intellectual ability.

One of the underlying issues is that the format of intelligence measures consists of presented problems. Problem finding, rather than problem solving, is thought to be associated with creative thought (Dillon, 1982; Getzels & Csikszentmihalyi, 1976). If it is true that good problem solvers do not necessarily make good problem finders, the implications would extend beyond the field of education. Large corporations complain about the quality of researchers, specifically their inability to find problems (Ferguson, 1978). The "ABD"

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(all-but-dissertation) status of many graduate students has also been attributed to this inability. The underlying issue implied in the research (Dillon, 1982; Guilford, 1975; Wakefield, 1988) is one of not knowing the strategies necessary to define problems. These strategies are different from those employed in solving problems.

An understanding of potential differences in processes involved in problem solving and problem finding may be gained by examining an attribute common to both. Spatial visualization was the attribute chosen for the present investigation. Spatial ability has been defined as a part of intellectual ability (Ekstrom, French, & Harmon, 1976; El Koussy, 1935; Lohman, 1979b) and has been associated with creative thought (Arnheim, 1969; Campbell, 1960; El Koussy, 1935; Kossylyn, 1985; McKim, 1978; Perkins, 1981; Shepard, 1978; Smith, 1964). Spatial visualization, one of the few subfactors identified in spatial ability (Carroll, 1974; Eliot, 1983; French, 1951; Guilford, 1967; McGee, 1979) is interpreted as an ability to manipulate objects in the imagination or to comprehend imaginary movement in a three-dimensional space (French, 1951). This subfactor most closely resembles the reports of mental imagery associated with creative thought (Ghiselin, 1952; Koestler, 1964).

The term "creative thought" implies a process definition of creativity. Other perspectives on creativity research have focused on personality attributes, dimensions of the creative product, or environmental influences on creative performance. The concern here lies with the cognitive processes that occur in an act of creation. This realm holds the greatest potential for educational research and implementation in the educational process. Unfortunately, there remain many gaps in our knowledge, and only inferential evidence to support the various theories of the processes involved in creativity (Tannenbaum, 1983).

Johnson-Laird (1988) used the following definition of creativity:

> A term used in the technical literature in basically the same way as in the popular, namely, to refer to mental processes that lead to solutions, ideas, conceptualizations, artistic forms, theories or products that are unique and novel. (p. 203)

An operational definition of creative thinking may be developed if one considers the act of problem-finding or defining as a reflection of the creative-thinking process. In an article on creative thought, Campbell (1960) quoted the mathematician Paul Sourriau (1881) on this issue:

> It is said that a question well posed is half-answered. If so, then true invention consists in the posing of questions. There is something mechanical, so to speak, in the art of finding solutions. The truly original mind is that which discovers problems. (p. 385)

With this in mind, the following operational definition is proposed: Creative thinking is a process in which the individual finds, defines, or discovers an idea or problem not predetermined by the situation or task.

Getzels and Csikszentmihalyi's (1976) landmark study described two distinct phases of this creative thought process as (a) a problem-finding phase and (b) a problem-solving phase. Similarly, in a study of artists and non-artists, Patrick (1937) described two succinct phases of thought with characteristics that led to the description of (a) unorganized and (b) organized thought. Problem finding or defining is found in most of the theories that propose steps to creative thought (Bain, 1855; Campbell, 1960; Csikszentmihalyi, 1988; Dewey, 1910; Getzels & Csikszentmihalyi, 1976; Mansfield & Bussé, 1981; Osborn, 1963; Perkins, 1981; Rossman, 1931; Sternberg, 1988; Von Fange, 1955; Wallas, 1926). In the present study, problem finding was defined as the formulation of a problem by an individual prior to the actions taken to solve the problem. Thus, the solution to the problem is directed by the initial parameters set by the individual in his or her chosen definition of the problem. This differs form problem solving which is defined as the process of finding a solution to a stated problem. Convergent problem-solving tasks, as exemplified in psychometric measures of spatial ability, require the identification of one correct response. Divergent problem-solving tasks require the formation of a quantity of solutions to a problem, for example, generating a list of uses for an object.

Statement of the Problem

The purpose of the present investigation was to explore the relationship between problem solving (the process of finding a solution to a stated problem) and problem finding (the formulation of a problem prior to the actions taken to solve the problem) in the manipulation of figural symbol systems by professional artists, semiprofessional artists, and nonartists. The possibility that these thought processes may be qualitatively different for certain individuals is supported in the literature by comparisons of expert and novices (Chi, Feltovich, & Glaser, 1981; DeGroot, 1965; Schoenfeld & Herrmann, 1982). For example, DeGroot (1965) concluded that the actual problem-solving process involved in chess mastery differs between the expert and the novice chess player both quantitatively and qualitatively. Variables that measure (a) the speed of the performance on a task (latency) or (b) the accuracy attained in the performance define the proficiency in which a task is achieved. Analysis of these variables can only measure quantitative differences. Differences in the type or quality of the processes employed in problem-solving (Chi et al., 1981; Kanevsky, 1990) and problem-finding (Beittel & Burkhardt, 1963; Getzels & Csikszentmihalyi, 1976) situations have been observed through the analysis of dynamic process variables.

In their work on problem-defining behaviors of art students, Getzels and Csikszentmihalyi (1964, 1976) reported that creative art students behaved in a discovery-oriented manner. The description of the activity that took place from the time that the student began drawing to the completion of the task was marked by three types of observed behavior: "openness of the problem structure, discovery-oriented behavior, and changes in problem structure and content" (Getzels & Csikszentmihalyi, 1976, p. 98). The percentage of total drawing time that elapsed before the final structure of the drawing contained its essential elements was calculated to determine the score for openness to the problem structure. The greater the amount of time, the higher the score. For discovery-oriented behavior, a low score was given if the student drew without interruption. Thus, this research suggests that, in the problem-finding stage of creative thought, the observed behavior would be characterized by a longer reaction time and more pauses for individuals associated with creative thought. Similarly, the fluency factor described by Guilford (1967) describes a tendency to prefer a divergent process that explores more than one alternative to a solution.

Based on the research available, with an emphasis on the findings of Egan (1979), Getzels and Csikszentmihalyi (1976), and Lohman (1979a, 1979b), the following hypotheses were advanced:

1. The group means of the scores on the psychometric measures of spatial visualization will be significantly different.

2. Reaction time between reading a question on a problem-solving test of spatial visualization and the subject's response time will be greater for the professional artists when compared to the semiprofessional artists, and greater for the semiprofessional artists than the nonartists.

3. Reaction time between question formation and response in a problem-finding (defining) task of spatial visualization will increase between the nonartists and the semiprofessional artists, and between the semiprofessional artists and the professional artists.

4. In the problem-finding tasks, the number of pauses in physical manipulation once the activity was initiated will be greater in the professional artists than in the semiprofessional artists. The number of pauses will be greater for the semiprofessional artists than for the nonartists.

5. The number of completed alternative transformations (or different ideas) explored in a problem-finding task of spatial visualization will be greatest for the professional artists, and will be greater for the semiprofessional artists than for the nonartists.

Method

Subjects

Sixty subjects were selected representing three independent groups of 20 each. Each group consisted of 10 male and 10 female participants. Twenty adult visual artists, 10 sculptors and 10 painters, who regularly exhibited their work in museums or galleries and earned their living solely through the production of art constituted the group of professional artists. The group of semiprofessional visual artists consisted of individuals who had formal art training beyond high school and produced ideas in art but did not earn their living producing ideas in the field. The nonartists were graduate students in education and psychology. They have had no formal art training since high school and reported that they did not produce ideas in art under any circumstances.

Measures

Spatial Ability Measures. The Guilford-Zimmerman (1956) Aptitude Survey's subtest of spatial visualization, Part VI, Form B was used as the first psychometric measure of spatial visualization. The Surface Development test published by the Educational Testing Service (Ekstrom et al., 1976) was used as the second measure of spatial visualization. Whereas the Guilford-Zimmerman instrument is a rotation or movement-type test of spatial visualization, the Surface Development test exemplifies what Lohman (1979a) described as a construction test. It requires the examinee to construct a mental image by reorganizing the stimulus from an unfolded pattern of a form to the constructed three-dimensional form.

Problem-Solving Task. The problem-solving activity (Task 1) contains eight of the problems found on the Cognition of Figural Transformations (CFT) subtest of the Structure of Intellect (SOI) test (Meeker & Meeker, 1969). This task requires the examinee to match the stimulus with the response that exemplifies a rotated version of the original stimulus.

Problem-Finding Tasks. The problem-finding activities chosen for the study were two puzzle-type games available on the consumer market. The use of play activities for an analysis of cognitive behavior is based on the work of Welker (1961) in which the behavior mechanisms characteristic of exploratory behavior and play were proposed as being responsible for "the variable and dynamic acts which characterize exploration, play, adaptable problem solution and invention" (p. 226). Play activities that are limited to figural transformations probably transcend limitations of age or areas of expertise because the skills required appear to be based on perceptual knowledge. The use of games rather than an activity such as drawing (Getzels & Csikszentmihalyi, 1976; Patrick, 1937) should offer a direct perspective on inherent differences in cognitive processes without the confounding of extensive previous experience by one (or more) group(s) with the task. In other words, to compare the drawing procedure of those who draw and those who do not cannot help to address clearly the issue at hand.

The first problem-finding task (Task 2) was a dissection puzzle called a tangram. The method of play used for this research is a problem-finding approach in which subjects must find ways to depict objects of their choice with the seven pieces. The second problem-finding puzzle (Task 3) was entitled "Pablo." It has pieces to to be manipulated, as well as connected, and was chosen for its divergent capabilities as a task of figural transformations.

Procedure

All participants received the same instructions. Upon arrival, an attempt was made to make the subject feel comfortable and relaxed. The purpose and procedure of the study were stated as follows:

> There will be two measures of spatial ability and three different tasks that I will ask you to complete. I will be videotaping so that I can play the tape back for you. At that time I will ask you to tell me what you were thinking about while you were playing. If you want to talk about what you are doing as you are doing it; please feel free to say anything at any time. Anything you say or think will help me to evaluate the usefulness of the two games as learning tools.

Scoring and Data Analysis

Two sets of data were provided by the videotapes: *proficiency variables* and *process variables*. The proficiency variables allowed tests of the five hypotheses advanced prior to the investigation. The scores were derived for the three groups on each of the two spatial visualization measures. Also, the mean reaction time between looking down at the questions on the problem-solving test (Task 1) and marking the answer box was calculated using the videotape and a professional stopwatch. The response time between the subject grasping the bag of materials and the completion of the problem-finding task, for both tasks, was calculated for each subject using the same techniques. In the problem-finding tasks, pauses were operationalized as the time span from the subject's touching the bag of materials to the completion of the task. Pauses or interruptions were defined as any time in which (a) the subject was looking at the game but not touching any of the pieces or (b) the subject has tactile contact with the shape(s), but no movement of objects was taking place. Finally, the number of alternative transformations was calculated for each subject. A distinct transformation was defined as a separately constructed configuration.

Process data were derived from both the problem-solving and problem-finding tasks. Getzels and Csikszentmihalyi (1976) defined two distinct phases of the creative thought process: a problem-finding phase and a problem-solving phase. In the present investigation, Phase 1 of the problem-defining tasks began at the moment the subject grasped the container of materials and ended at the moment that the subject put together the first two game pieces that *remained in the final product*. Phase 2 began when the first two game pieces were permanently positioned and ended when the subject indicated that he or she had completed the task.

With the problem-finding tasks, the reaction time and number of pauses for each of the two phases in each of the two games were calculated, yielding eight variables. The number of dimensions that were employed by the subject in defining the product (in each game) identified another process variable. Five dimensions were identified and defined as: (a) two-dimensional— the product was made on a flat plane; (b) three-dimensional— height was added, yielding a sculptural product; (c) motion— actual or implied movement in the construction of the product; (d) time— the intentional use of time as a change agent for the product; and (e) the use of other materials incorporated into the final product. The number of perspectives (in which the subject changed positions or rotated the work-in-progress) was also used. Every time there was a change in the angle from which the piece was viewed (by the subject), the perspective variable was incremented by one.

Based on the process variables defined by Getzels and Csikszentmihalyi (1976), two other variables were included for analysis. The number of times that the pieces (in either game) were removed or repositioned was counted, and used as a process variable. The second was defined as the number of game pieces employed by that subject.

Results

Cochran's test was used to test the assumption of homoscedasticity. Variables for which the assumptions were met were subjected to an ANOVA. Where a significant *F* was found, the Scheffe test was employed for the post-hoc contrasts. Many of the variables did not meet the necessary assumptions. The method chosen for handling the unequal variances and nonnormality was a logarithmic transformation. Unsuccessful attempts to relieve the heterogeneity of variance or meet the distribution assumption resulted in the use of a nonparametric measure, namely the Kruskal-Wallis test.

Proficiency Variables

Hypothesis I. The null hypothesis of no differences between group means on the spatial visualization measures was supported by the analyses using the Guilford-Zimmerman Test of Spatial Visualization, $F(2,57) = 0.23$, $p = .79$ and the Surface Development Test, $F(2,57) = 1.37$, $p = .26$.

Hypothesis II. No significant differences were found between groups for reaction time in problem-solving, $F(2,57) = 0.33$, $p = .96$.

Hypothesis III. The difference in total reaction time demonstrated by the groups was significantly different for the Tangram game, $F(2,57) = 6.65$, $p = .0025$ as well as for the Pablo game, $F(2,57) = 13.21$, $p = .000$. The Scheff procedure identified Group 2 (the semiprofessional artists) as having significantly higher reaction times ($p = .05$) than the other two groups. Descriptive statistics are presented in Table 1.

Hypothesis IV. The difference between groups in the total number of pauses was significant in both the Tangram activity, $F(2,57) = 5.49$, $p = .0045$ and the Pablo activity, $F(2,57) = 9.81$, $p = .0002$. The semiprofessional artists had more pauses ($p = .05$) than the other two groups.

Hypothesis V. The Kruskal-Wallis test yielded significant results for group membership on the number of transformations completed in the Tangram game, $\chi^2\ (2) = 8.06$, $p = .0178$ but not in the Pablo game, χ^2

Table 1
Means and Standard Deviations of Original Variables for Each Group (each n=20)

	Group 1 Artists		Group 2 Semi-Professionals		Group 3 Nonartists	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
AGE	49.55	10.77	39.25	7.87	35.10	7.52
GZ	11.60	6.74	13.03	6.10	12.11	7.27
SURDE	32.39	17.35	37.69	11.10	30.41	13.97
RTPS	329.40	185.86	343.65	274.46	345.95	186.73
PSC	4.25	1.86	4.90	1.55	4.55	2.06
PSA	7.40	1.43	7.95	0.22	7.80	0.62
TRT	181.20	151.93	387.50	337.16	133.05	79.09
TRTONE	54.30	51.71	138.75	152.33	66.90	63.04
TRTTWO	123.05	140.02	248.70	251.41	66.15	44.89
TTPAUSE	5.70	6.17	14.60	13.98	5.25	4.58
TPONE	1.65	1.98	4.50	6.03	3.30	4.09
TPTWO	4.05	5.05	10.10	10.56	2.00	1.81
TTRANSFO	1.65	1.39	4.65	8.87	1.00	0.00
TNODIM	1.60	0.82	1.80	0.70	1.10	0.31
PRT	742.35	450.65	1775.55	1099.15	661.65	763.41
PRTONE	135.40	137.14	189.45	212.53	154.05	116.00
PRTTWO	604.75	414.68	1586.10	993.50	507.50	772.27
PTPAUSE	19.40	16.19	45.65	36.04	13.65	10.26
PPONE	2.45	4.24	3.10	2.75	5.90	6.01
PPTWO	16.95	15.64	42.55	34.48	7.75	6.90
PTRANSFO	1.65	1.35	2.45	2.21	1.30	1.13
PNODIM	2.05	0.51	2.25	1.44	1.75	0.72
PERSPECT	18.15	12.93	41.45	35.93	4.65	6.63
PCHANGE	27.55	26.06	50.10	24.80	40.00	32.29
PPIECES	23.25	14.25	41.95	25.42	19.55	14.79

Note. Response times were calculated to the nearest second. The variable labels are abbreviations: GZ, Score on the Guilford-Zimmerman measure; SURDE, Score on the Surface Development measure; RTPS, Total response time on problem-solving task; PSC, Number correct on problem-solving task; PSA, Number attempted on problem-solving task; TRTONE, Response time on Tangram phase one; TRTTWO, Total response time on Tangram phase two; TTPAUSE, Total number of pauses on Tangram; TPONE, Total number of pauses on Tangram phase one; TPTWO, Total number of pauses on Tangram phase two; TTRANSF, Total transformations on Tangram; TNODIM, Total number of dimensions on Tangram; PRTONE, Response time on Pablo phase one; PRTTWO, Response time on Pablo phase two; PTPAUSE, Total number pauses on Pablo; PPONE, Total pauses on Pablo phase one; PPTWO, Total pauses on Pablo phase two; PTRANSF, Total transformations on Pablo; PNODIM, Total number of dimensions on Pablo; PERSPEC, Number of perspectives view while working on Tangram or Pablo; PCHANGE, Number of times that game pieces were removed or repositioned while working on either game; PPIECES, Number of game pieces used for Pablo construction.

(2) = 4.69, $p = .096$. The semiprofessionals differed significantly from the other two groups by completing many more transformations with the tangram game.

Process Variables

Two raters scored the videotapes of three subjects, one randomly selected from each group. The interrater reliability coefficients were .97 for the response time variable and .93 for the numeric variables.

Correlation matrices were used to identify variables that could be removed, reducing the number of variables subjected to factor analysis. The important distinction between Phase 1 and Phase 2 activities within a task ne-

Table 2

Correlation Matrix for Tangram Analysis with Decimal Points Omitted

	2	3	4	5	6	7	8	9	10
CZ	79**	-11	24	-01	-05	06	02	-09	09
SURDE		-10	44**	07	03	00	16	-09	34*
LRTPS			12	32	-02	18	08	-10	10
PSRATIO				-23	-07	-09	09	-16	02
LTRTONE					28**	63**	47**	10	23
LTRTTWO						21	71**	37**	39**
LTPONE							35*	18	12
LTPTWO								30	45**
TNODIM									26*
LPERSPEC									

Note. CZ, Score on the Guilford-Zimmerman measure of spatial visualization; SURDE, Score on the Surface Development measure of spatial visualization; LRTPS, Logarithmic transformation of the response time on the problem-solving task; PSRATIO, A ratio of the problems correctly answered over he number of problems attempted; LTRTONE, Logarithmic transformation of the response time in Phase 1 of the Tangram grame; LTRTTWO, Logarithmic transformation of the response time in Phase 2 of the Tangram game; LTPONE, Logarithmic transformation of pauses in Phase 1 of the Tangram game; LTPTWO, Logarithmic transformation of pauses in Phase 2 of the Tangram game; TNODIM, The number of dimensions utilized for the Tangram game; LPERSPEC, Logarithmic transformation of the number of perspectives viewed by the subject while working on either the Tangram or the Pablo game. Response times were calculated to the nearest second.

$*p = .05$. $**p = .005$. (2 tailed).

Table 3

Correlation Matrix for Pablo Analysis with Decimal Points Omitted

	2	3	4	5	6	7	8	9	10	11	12	13
CZ	79**	-11	24	-17	-09	-05	01	-15	00	10	-11	-23
SURDE		-10	44**	-34	03	-25*	14	08	12	34*	-00	-07
LRTPS			12	18	15	15	19	-00	05	10	17	06
PSRATIO				-13	-06	-06	04	-01	16	02	07	-14
LPRTONE					23	84**	26*	06	01	-07	38**	03
LPRTTWO						08	89**	28*	47*	75**	51**	77**
LPPONE							09	05	-06	-17	29*	-10
LPPTWO								22	49**	72**	51**	69**
LPTRANSF									06	27*	04	35*
PNODIM										52**	27*	46**
LPERSPEC											23	58**
LPCHANGE												30*
LPPIECES												

$*p = .05$. $**p = .005$. (2 tailed). Variables beginning with L are Logarithmic transformations.

cessitated the deletion of the variables that depicted the total response time of each activity. The remaining 19 variables were divided into: (a) the problem-solving variables, (b) the variables identified in the Tangram task, and (c) the variables defined by the Pablo task. Theoretically, the two problem-defining tasks should yield the same underlying factors. With this assumption and the constraints of a small sample ($N = 60$), separate factor analyses were conducted in the following manner:

1. A factor analysis of the problem-solving variables and the Tangram variables (see Table 2 for correlation matrix for this analysis).

2. A factor analysis of the problem-solving variables and the Pablo variables (see Table 3).

3. A separate analysis for each group of subjects using the problem-solving variables with each of the variable sets found in the separate games ($n = 20$). This provided six distinct analyses which had the potential to uncover differences in the underlying factorial relationships of the variables depending on group membership. A principal-components analysis was used with rotation to an oblique solution.

Factor Analyses

Four components with eigenvalues greater than or equal to 1.0 were retained for both the Pablo and the Tangram analyses. These components were then rotated to an oblique solution by the direct oblimin method with delta equal to 0.0. The four factors retained accounted for 71.8% of the total variance in the Pablo analysis and 73.8% in the Tangram analysis.

Although separate analyses were conducted, the similarity of the underlying factors that emerged warrants a combined report. Tables 4 through 7 show for each factor: (a) the name of each variable with a loading equal to or greater

Table 4

Loadings and Descriptions of Variables on Factor 1: Problem Restructuring

Variable	Behavior of Subjects with High Scores onthe Variable	Loading on Pablo Analysis	Loading on Tangram Analysis
LPRTTWO	Long response time in Phase 2 of Pablo game	.94	(NA)*
LPPTWO	Large number of pauses in Phase 2 of Pablo game	.88	(NA)*
LPPIECES	The use of many game pieces in the Pablo task	.84	(NA)*
LPERSPEC	A large amount of different perspectives viewed	.84	.69
PNODIM	Many dimensions considered when building the Pablo construction	.61	(NA)*
LPCHANGE	Large number of game pieces were removed or repositioned during construction process	.55	(NA)*
LPTRANSF	A large number of different transformations were made with the Pablo game	.38	(NA)
LPTPTWO	Large number of pauses in Phase 2 of Tangram game	(NA)	.85
LTRTTWO	Long response time in Phase 2 of Tangram game	(NA)	.85
TNODIM	Many dimensions considered when building the Tangram construction	(NA)	.58
		Pablo	Tangram
Percentage of total variance accounted for		31.4	28.1

*NA = not analyzed.

Table 5

Loadings and Descriptions of Variables on Factor 2: Problem Solving

Variable	Behavior of Subjects with High Scores on the Variable	Loading on Pablo Analysis	Loading on Tangram Analysis
SURDE	Completed a large number of questions correctly resulting in a high score on Surface Development test	.93	.95
CZ	Completed a large number of questions correctly resulting in a high score on Guilford-Zimmerman test	.91	.90
PSRATIO	Of the problems attempted, a large number of the problem-solving questions were answered correctly	.48	.50
		Pablo	Tangram
Percentage of total variance accounted for		19.8	21.2

Table 6

Loadings and Descriptions of Variables on Factor 3: Problem Defining

Variable	Behavior of Subjects with High Scores on the Variable	Loading on Pablo Analysis	Loading on Tangram Analysis
LPRTONE	Long response time in Phase 1 of Pablo game	.95	(NA)*
LPPONE	Large number of pauses in Phase 1 of Pablo game	.93	(NA)*
LPCHANGE	Large number of game pieces were removed or repositioned during construction process	.46	(NA)*
LPPTWO	Large number of pauses in Phase 2 of Pablo game	.37	(NA)*
SURDE	Completed a large number of questions correctly, resulting in a high score on Surface Development test	-.31	—
LTRTONE	Long response time in Phase 1 of Tangram game	(NA)*	.89
LTPONE	Large number of pauses in Phase 1 of Tangram game	(NA)	.85
LTPTWO	Large number of pauses in Phase 2 of Tangram game	(NA)	.38
LRTPS	Long response time in the problem-solving task	—	.33
PSRATIO	Of the problems attempted, a large number of the problem-solving questions were answered correctly	—	-.40
		Pablo	Tangram
Percentage of total variance accounted for		12.7	14.1

*NA = not analyzed

than .30; (b) a description of the behavior of the subject based on the variable; (c) the respective loadings on each of the analyses, with "NA" indicating the variables that were not entered into that particular analysis; and (d) the percentage of the total variance accounted for by the factor in each of the analyses. Correlations among the factors ranged from .01 to .23 with a median of .11.

The five variables that were shared between the two analyses loaded on factors in the same direction and with similar intensity. Also, the percentage of total variance accounted for by each factor was approximately the same in both analyses. The first factor that emerged accounted for 31% of the total variance in the Pablo task and 28% in the Tangram task. The patterns of relationships between the variables were very similar in both of the problem-defining tasks.

The first factor was tentatively labeled Problem Restructuring. The vari-

Table 7

Loadings and Descriptions of Variables on Factor 4: Undefined

Behavior of Subjects with High Scores on the Variable	Loading on the Variable	Loading on Pablo Analysis	Loading on Tangram Analysis
LRTPS	Long response time in the problem-solving task	.74	.79
PSRATIO	Of the problems attempted, a large number of the problem-solving questions were answered correctly	.67	.62
LPCHANCE	Large number of game pieces were removed or repositioned during construction process	-.34	(NA)*
TNODIM	Many dimensions considered when building the Tangram construction	(NA)	-.41
		Pablo	Tangram
Percentage of total variance accounted for		8.0	10.5

*NA = not analyzed

ables that had substantial loadings here involved an increase in the amount of time and changes that occurred in the second phase of the problem-defining tasks. The other variables associated with this factor involved an increase in time or changes in the course of action, particularly in association with the second phase of the game tasks. It is this association with the second phase of the tasks that differentiated this first factor, labeled Problem Restructuring or Redefining, from the Problem-Defining factor (Factor 3). The Problem Defining factor was more closely associated with the first phase of the game tasks. Theoretically, one would need to define the problem (Phase 1) prior to solving it. Restructuring could only occur after the first structure was abandoned (Phase 2). The number of pieces removed or repositioned was the only variable that loaded on both factors.

The second factor was labeled Problem Solving. The three variables that defined this factor are associated with the ability to solve spatial tasks. The percentage of total variance accounted for by this factor was 19.8% on the Pablo task and 21.2% on the Tangram task.

Similar in structure to Factor 1, the distinguishing characteristic of the third factor was its association with Phase 1 rather than Phase 2 of the problem-defining tasks. This factor was tentatively labeled Problem Defining. Theoretically, one would need to define the problem prior to solving it (Phase 1), but restructuring would occur only after the first structure was abandoned (Phase 2). This factor accounted for 12.7% and 14.1% of the total variance in the Pablo and Tangram tasks respectively. The fourth factor remained undefined.

Subsequent to this analysis, within-group (n=20) analyses were conducted in the same manner to check the stability of the relationship between variables and the underlying factors among the various subgroups. Variability was most apparent in the analysis of the Tangram variables within Group 2 (the semiprofessional artists). This analysis failed to converge in 25 iterations, thus refusing an oblique rotation. The complexity of the interpretation caused by the demonstrated variability of the relationship between these variables and the underlying factors, as a function of group membership, suggested a discriminant analysis to continue the pursuit of variables that best discern group differences.

Discriminant Analysis

A stepwise discriminant analysis was used to eliminate the less useful variables. The final analysis employed nine variables, identified in Table 8.

Two significant discriminant functions were derived from the analysis. Function 1 explained 76.5% of the variance, and Function 2 explained the remaining 23.5%. Canonical correlation coefficients of .79 ($p < .0001$) and .59 ($p = .0053$) between the groups and the discriminant function revealed a strong association in both cases.

The evaluation of the discriminant functions at the group means (group centroids) indicated that Function 1 discriminated Group 3 (nonartists) from Groups 1 and 2 (professional and semiprofessional artists). Function 2 discriminated the professional artists (Group 1) from the semiprofessionals (Group 2).

The correlation between the discriminant variables and the discriminant function was used to define the function. The mean scores indicated that the number of perspectives and the number of dimensions made the greatest contribution to the first function. A narrow approach to problem defining seems to be implied. The pauses and response time in both Phase 1 and Phase

Table 8
Variables Used to Discern Group Differences

Step	Variable	Wilks' Lambda
1.	Perspectives viewed	.59*
2.	Change in position	.48*
3.	Number of dimensions	.42*
4.	Response time in phase II of tangram	.39*
5.	Pauses in phase I of Pablo	.37*
6.	Response time in phase I of Pablo	.30*
7.	Pauses in phase II of Pablo	.29*
8.	Response time in phase II of Pablo	.26*
9.	Score on the Surface Development Test	.24*

Percentage of Explained Variance

Function	Eigenvalue	Percentage of Variance	Cumulative Percent	Canonical Correlation
1	1.69	76.48	76.48	.79
2	0.52	23.52	100.00	.59

Significance

After Function	Wilks' Lambda	Chi-Squared	D.F.	Significance
0	0.24	73.34	18	.0000
1	0.66	21.80	8	.0053

2 of the Pablo task contributed the most to the discriminant score. The mean scores indicated that the nonartist had more pauses in Phase 1, yet had fewer pauses in Phase 2, than the other two groups. This supports the observation that the nonartists were more tentative in the problem-finding phase and more decisive in the problem-solving stage of the Pablo task.

Function 2 discriminated the professional artists from the semiprofessionals. The function is described by the use of fewer pieces, fewer changes in the pieces or their positions, a faster response time, and fewer pauses in Phase 2 (problem-solving) of the Pablo task for the professional artists. The variables that contribute the most to the discriminate score were found in the second phase of the Pablo task, with time contributing slightly more than pauses. Again, referring to the mean scores, the professional artists took less time and had fewer pauses in both phases of the Pablo activity and made fewer changes (or discovery-oriented behavior) than the semiprofessional artist.

Discussion

Quantitative Findings from the Proficiency Variables

No differences in power or proficiency were detected between the three groups on the spatial visualization measures or the problem-solving task. Although differences may exist, they could not be detected by the measures used in this study. One possible reason for this inability to detect differences may be found in the emphasis on speed that is employed in psychometric measures. As Lohman (1987) stated, "individual differences in speed of solving simple problems is generally a poor predictor of how complex a problem one can solve" (p. 203). Another possible explanation involves Egan's (1978) theory that tasks of spatial visualization include an encoding process as well as the process of mentally transforming the object. It is possible that one group might have difficulty encoding the information, but no trouble visualizing a change in position, while another group might have the opposite reaction— resulting in the same score. The variety of possible problem-solving strategies (other than visualization) that can be or are required by these measures also causes difficulty in forming conclusions.

The second major finding in this part of the investigation was that of the relationship between group membership and discovery-oriented behavior. Like Getzels and Csikszentmihalyi's (1976) more creative art students, the professional artists were expected to take longer, pause more, and design more transformations than the semiprofessional artists, who would in turn outperform the nonartists. This, however, was not the case. The significant differences between the groups existed between the semiprofessional artists and the other two groups. The semiprofessional artists behaved in the same manner as the art students involved in the Getzels and Csikszentmihalyi study. However, based on these initial variables, the professional artists did not differ from the nonartists. Patrick's (1937) study of creative thought in artists and nonartists supports the results of this study in that she found no quantitative differences between these two groups in the overall time spent on the task.

The lack of support for the findings

reported by Getzels and Csikszentmihalyi (1976) was quite unexpected. It is possible that the discovery-oriented behaviors described by Getzels and Csikszentmihalyi (1976) may be necessary for students involved in the initial stages of learning how to produce their own ideas in art. This would explain the similarity between their art students and the semiprofessional artists in this study who, by definition, were not involved with the production of ideas in art to the degree that professional artists were. An alternative or associative explanation may be found in generalizing the findings presented in the research on expert versus novice chess players (DeGroot, 1965). It is possible that the professional artists, by their intense experience, knew what would fail, eliminating the need for extensive explorations.

Similarities in Problem-Finding Behavior

The opportunity to review the behaviors that occurred during the playing of the games revealed two distinct phases of behavior. The first phase was characterized by less physical activity, a seemingly slower rate of movement, more contemplation, and what appeared to be observational techniques. The beginning of the second phase was quite apparent in most cases. Once the initial pieces were formed, the type and speed of activity altered. Recall that operationally defined, the first phase began from the time the task was handed to the participant and ended at the point when the first two pieces (that remained in the final product) were arranged. The second phase began at that point and ended when the subjects indicated they were finished. This is reminiscent in flavor of the phases of unorganized and organized thought described by Patrick (1937) in her study of artists and nonartists as well as the two phases defined by Beittel et al. (1963) and Getzels and Csikszentmihalyi (1976) as the problem-defining stage and the problem-solution stage in their population of art students. This finding suggests that these observed behaviors are not bound by, or characteristic of, just the artistic processes involved in drawing.

Differences in Problem-Finding Behavior

In spite of this overall similarity among groups, differences were also noted. In Phase I, where the nonartists exhibited more pauses and interacted less with the materials, the semiprofessionals manipulated and physically categorized the information presented, resulting in fewer pauses than exhibited by the nonartists. The professional artists did not show attempts at categorizing the materials through their overt behaviors. Sifting through the pile of pieces, pausing to examine a piece of the puzzle at times, then returning it to the pile is a more representative description of the behavior of most of the professional artists. The second phase of activity appeared more organized in all three groups.

Nonartists. The first function discriminated the nonartists from the other two groups. Explaining 76% of the total variance, the first function tends to support the clinical observations that the nonartists appeared more tentative in the problem-finding phase and more decisive in the problem-solving stage of the Pablo game. The nonartists had more pauses in Phase 1 of the task and fewer pauses in Phase 2 than did the other two groups. The function was defined by the number of perspectives viewed and dimensions employed by the nonartist, implying a more narrow approach to problem defining.

Several interpretations of this function are possible. It might be that individuals with high intellectual ability, which these graduate students are presumed to have, would spend more time encoding the information (Sternberg & Davidson, 1984) before choosing a course of action. However, in this instance, this does not seem to be the case. Two findings support another interpretation. The entire sample in this study performed in a comparable manner on all of the problem-solving tests. Lohman (1987) provided evidence to support a positive relationship between scores on these measures and verbal intelligence measures. More convincingly, almost all of the participants had attended or taught college at the graduate level. It seems unlikely that the difference detected is one of intellectual ability.

The interpretation that seems to best fit the available data supports a difference in the approach to the situation. The strategy employed by the two groups of artists may be described as a visual-spatial thought process. Rather than directing a limited amount of information toward a goal that is sequentially determined or decided, a process of simultaneously addressing a large quantity of information can be used. A strategy of considering many perspectives of a variety of different alternatives characterizes the behavior patterns of the artists. For example, the verbal protocols indicate that the basis of a decision might involve the analysis of several variables (i.e., wrong color, right shape, good angle, but then needs a contrasting form emerging from the right of the piece). Returning to the pile of pieces, the artist would collect several pieces, one to replace the unsuccessful color of the previous piece and one to address the need for a contrasting piece. The positioning of several pieces was often followed by a rotating of the product (or changing the viewpoint of the artist) to assess the success of the decisions from different angles. The nonartists sought fewer perspectives and employed fewer dimensions to the problem. The strategy employed by the nonartists often included the consideration of only one variable at a time and viewing the product from other angles was not characteristic of the observed behavior. Of the 20 nonartists who participated, 6 produced a flat arrangement on the table, using only a few of the Pablo pieces. One of these participants did not produce anything after exploring the relationship of no more than two pieces of the puzzle at a time. The few nonartists who used several color schemes and created a 3-dimensional figural representation disclosed a minimal degree of encoding of the information. In reviewing the procedure from the videotape, Participant #11 described one of the most complex encoding processes by a nonartist:

> Well, I remember first being overwhelmed with how many different pieces there were and having a need to kind of categorize the different pieces so I could...taking inventory of just what was available. I remember at one point thinking...I don't have a convenient way to categorize all of these and started, after I got some of the very big pieces categorized, just made another sweeping categorization of all the little things.

The sense of feeling "overwhelmed" by the number of stimuli presented in the Pablo game was verbalized by most of the participants. The implicit strategy that was employed to deal with the situation varied tremendously. Whether this procedure occurred as a way of finding a problem or as a means of preparation prior to finding a problem cannot be discerned through this investigation. In the second phase, the nonartists paused less frequently than both of the other groups. This decisiveness may be attributed to the less complex nature of the defined problem.

Semiprofessional artists. The semiprofessional artists took the longest time in both phases of activity, made the most changes, had fewer pauses than the nonartists, but paused more than the professional artists. The behavior pattern of the semiprofessional artists was most similar to the pattern of behavior depicted by Getzels and Csikszentmihalyi (1976) of their more creative art students. The initial phase, analogous to Getzels and Csikszentmihalyi's problem-formulation stage, was characterized by behaviors that describe the discovery-oriented approach. Many game pieces were handled, a more thorough exploration was conducted as compared to that of the other two groups, and a greater number of changes in position or types of pieces occurred.

Professional artists. The second discriminant function discriminated the behavior of the professional from the semiprofessional artists. The information found in this study indicates that the professional artists took less time and had fewer pauses in both phases of the Pablo activity and made fewer changes (or discovery-oriented behavior) than the semiprofessional artists. The unexpected behavior pattern depicted in the clinical observations and confirmed by the second discriminant function finds little support in the previous literature on artists.

The expert-versus-novice differences described in the literature (Chi et al., 1981; DeGroot, 1965; Schoenfeld & Herrmann, 1982) may be relevant here. DeGroot (1965) discussed the probability that the expert chess master, afforded a greater depth and breadth of experience, is less likely to make unsuccessful attempts or changes due to his or her knowledge of what would fail. It is likely that professional artists have more opportunities than semiprofessional artists to manipulate figural information and to make and learn from mistakes.

Another phenomenon not cited in the literature appears also to be reflected here. Based on the clinical observations and verbal protocols, the professional artists who participated in this study exhibited a behavior that I have tentatively labeled a *personal aesthetic bias*. The distinctive aesthetic that guides their creative thought processes when producing ideas in art was reflected in the behaviors of a game task that does not purport to have any association with the complexity involved in the creative thought processes involved in producing art.

This personal aesthetic bias behaves like the engineering of a fine bridge, offering tensile strength to the pursuit of an idea. As in steel structures, this tensile strength supports the endeavor, yet it bends or flexes in response to the forces that act upon it. The personal aesthetic framework seems to form an organizing principle for the professional artists' perceptual information gathering and consequent thought processes. This aesthetic appears to guide the search operation, providing a selective criterion within which one explores (Campbell, 1960). There are references in the literature to aesthetic characteristics of creative thought which help to shape a correct solution (Campbell, 1960; Perkins, 1981), but the idea of an aesthetic preference that guides the perception of new experiences has not been previously suggested.

It appears that this aesthetic preference may have altered the perception of this task into a problem-solving task rather than the problem-defining task it was originally designed to be. In that the professional artists begin the task with a particular set of conventions that have emerged from their own work, the application of these conventions to the task can be viewed as a problem to solve. The semiprofessional artists, not having the time to fully develop their own sets of conventions fully, would view the multiplicity of choices as a problem-defining or discovered problem situation (Getzels & Csikszentmihalyi, 1976), as would the nonartists due to their even more limited experience with transforming figural information.

The verbal accounts recorded during and after the session support this conclusion. A comparison of two sample reports, the first from a professional artist (male) and the second from a (male) semiprofessional artist, serves to illustrate the difference perceived on the Pablo task:

> ... I approached it as much more of a sculpture thing although it was very, call it "cardboard art" because these [pieces] are flat. I used them basically as silhouetted shapes, because you see, in all things in life; people, buildings, things, the first thing one sees is a silhouette. As you get closer you see 3-dimensional. And when you get even closer you may see the color or texture, and when you get closer you may get the smell...I don't look so much at the colors. I saw your little connectors and I thought it would be fun to make a little bit of a space structure. You know, since I work with circles and waves, I picked the circle and wave shapes...But look at the shapes in the background [points at one of his sculptures on the end table]. Isn't that interesting! Look at the repetition of form. This [Pablo piece] is a little bit of my language. (Participant #50).

The reaction of the semiprofessional artist on the Pablo task:

> Well, first you have to know what it does before you know what you can do with it. That kind of thing...so there's always a honeymoon, if you will...an adjustment process and then once you decide you can get the feel for it, then you do it, and that's what I'm used to doing in my work, especially when I am confronted with something that's new...(Participant #28)

As is apparent, the semiprofessional remains open to the available information, analyzing or sensing potential without directing his own perception. The artist, on the other hand, has a personal set of conventions (such as three-dimensional form, circles and waves, shapes, and the importance of the silhouette, in this instance) that is the basis of the language in his body of work. It is a language he knows well and is most interested in developing further.

One explanation of this new finding may be offered in terms of the difference in the level of professional growth attained in this population and in the Getzels and Csikszentmihalyi (1976) study. The use of second-and third-year art students in the earlier study may not be an accurate measure of a mature problem-finding process. Students studying style and technique while discovering what it is that they wish to address through their work may, in fact, be in a discovery-oriented stage of development. The final stage, however, may contain a narrower and sharper focus which translates into a unique personal style.

Conclusion

The visual and verbal data suggest that three different approaches were taken to the problem-defining tasks. In general, a very limited amount of information was attained, organized, and incorporated by the nonartists. The other two groups perceived a multitude of information and then used strategies to cope with that amount of information. The semiprofessionals used discovery-oriented behavior (Getzels & Csikszentmihalyi, 1976) to establish rules to organize the information. The professional artists used a personal aesthetic that guided their ideas in art as an organizing principle.

The results support the description of those who produce ideas in art as people who seem to process the interrelationship of many variables simultaneously rather than directing a limited amount of information toward a goal that is sequentially determined and decided. Seeking many perspectives and dimensions of a solution appears to be spatial in character. One implication derived from the results of this study is that a visual-spatial thought process may be necessary to capture the essence of the whole form in order to define a problem to be solved. If this is so, similarities in problem-finding behavior may be found in other populations (i.e., scientists, entrepreneurs, mathematicians). Often referred to as nonverbal or spatial thought, research involved in the inventiveness of the scientific process has cited this strategy as necessary to creative endeavors:

> As the scientific component of knowledge in technology has increased markedly in the 19th and 20th centuries, the tendency has been to lose sight of the crucial part played by nonverbal knowledge in making the "big" decisions of form, arrangement, and texture that determine the parameters within which a system will operate. (Ferguson, 1978, p. 46)

More specifically, if a visual-spatial thought process is strategically more useful in some situations (i.e., topology maps, balancing a chemistry equation) than a linear-sequential process, the nature and nurture of this ability must be investigated and incorporated into the educational system. Clues that substantiate this possibility already exist. Performance in higher mathematics, particularly in algebra and geometry, appears to require a spatial thought process. Although no specific question was asked, the verbal protocols indicate that of the 40 artists involved in this study, 32 mentioned their appreciation for at least one of these two courses in high school. The implication that a visual-spatial thought process is essential in some situations may hold true in other disciplines.

The results of the factor analyses offer evidence to support the idea that the thought processes involved in problem-solving are different from those involved in problem-finding. The first factor (problem-restructuring) and third factor (problem defining) held a slight negative relationship to the problem-solving factor (factor 2). If the ability to ask questions is different from the ability to provide answers, major curricular revisions are necessary at every level of our educational system. With the advancement of computer technology, our emphasis on human efforts to provide answers should give way to the development of the ability to ask questions– enhancing the usefulness of our computers as an essential tool and expanding our potential as creative individuals. At a most fundamental level, the skills necessary to develop questions may be the same skills needed to prevent boredom and provide personal entertainment. Creative individuals do not seem to have or allow time for boredom.

The constraints in which an investigation is formed are as critical as the possibilities that can be postulated in developing a knowledge base for further research.

Lacking a measure of verbal ability, this study could not address issues relating the performance on these figural tasks to performance on standard intelligence measures or the success attained in school-related activities. Originally thought to have added an unnecessary strain to the amount of assessment measures and length of time demanded by the study when soliciting volunteered adult participation, the potential value that that information would have had in explaining the results was not realized. Unfortunately, the research on the relationship that measures of spatial ability have with intellectual ability does not have the strength, at this point, to support interpretation.

A second consideration involves the spatial visualization measures employed in this investigation. A problem-solving task and spatial visualization measure that only require the ability to transform images mentally in seeking the solution must be found.

Although 60 subjects were sought, the number of variables that evolved when addressing the dynamic aspects of the observed processes merited a larger sample. The nature of the multivariate analyses conducted in this study must be viewed as one of exploration. With this perspective, the information presented from the analyses must be used to raise issues and ask questions rather than resolve them.

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