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ABSTRACT

The prediction of creativity is an intricate and difficult problem for which there is no currently accepted method of solution. At least two conceptually discernable types of creativity are identifiable in research on the topic. The first type conceives creativity to be a trait which is distributed across the population in a fashion analogous to intelligence. The second type might be called the "state" concept of creativity. Its primary analytic tool is the examination of criterion creative groups compared to less creative ones. An eclectic approach to the practical application of predicting creativity permitted the use of several different methods of predicting creativity while making comparisons among them; this approach was utilized in the present study. Subjects were junior high school students who were the top scorers in two mathematics competitions held one year apart. They were administered a variety of paper and pencil measures. Test results indicated the creative potential of this group was quite high. (Author/BJG)

Creative Potential of Mathematically Precocious Youth

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The prediction of creativity is an intricate and difficult problem for which there is no currently accepted method of solution (Cattell & Butcher, 1968). The failure may be due as much to conceptual confusion as it is to psychometric inadequacy.

At least two conceptually discernible types of creativity are identifiable in research on the topic, and perhaps more. The first type conceives creativity to be distributed across the population in a fashion analogous to intelligence. In fact, the orthogonality of the two "unitary traits," creativity and intelligence, is still a major debate. It was sparked by the Getzels & Jackson (1962) study of "high IQ --low creativity" and "low IQ--high creativity" high school students. The methodology and interpretations in that study were sharply criticized by Burt (1962), who argued that no demonstration of creativity as different from intelligence had been made. Going even further, Cropley (1966) concluded from his research that "[i]t is unacceptable to think of creativity as a separate basic intellective mode [p. 264]." For some, it has close connections with Guilford's (1967) "divergent thinking-convergent thinking" distinction. The debate is not concluded, but it is clear that the discussion presumes creativity to be a trait which is distributed throughout the population.

The second type of creativity treated in the literature is what might be called the "state" concept of creativity. Its primary analytic

tool is the examination of criterion creative groups compared to less creative ones. MacKinnon (1962) was able to distinguish more creative from less creative architects (as rated by peers) on a number of affective measures. Cattell & Drevdahl (1955) identified consistent differences between eminent researchers and eminent teachers and administrators. Parloff (1966) studied adolescents as well as adults who were rated more and less creative.

A review of previous research is replete with examples of concern with both types of creativity (Freeman, Butcher, & Christie, 1968). In terms of the highly creative person, the first type would characterize him as "possessing a great deal" of creativity. The second type would search for how the identified "creative" person is different from less creative people on a number of dimensions.

The uncertain "state of the art" with regard to the prediction of creativity demands an eclectic approach in practical applications. The use of several different methods of predicting creativity also permits comparisons among them. These comparisons have two bases: First, the current agreement of the instruments with each other; second, their eventual success in predicting an outcome within a longitudinally based study.

Such an opportunity presents itself in the Study of Mathematically and Scientifically Precocious Youth at Johns Hopkins University. A group of exceptionally able junior high school students has been identified through two large scale mathematics competions. The composition and ability level of the group have been described in detail elsewhere (Keating & Stanley, 1972; Keating, in press), but suffice it to say that the mean score of the 71 students in the group on the College

Entrance Examination Board's (CEEB) Scholastic Aptitude Test--Mathematical (SAT-M) was 660--and the two top scorers earned 800. The youngest student at the time of the testing was 12 years 2 months old (and earned one of the 800's); the oldest, 14 years 2 months.

These students, then, are among the mathematically ablest students of their age group in the country, and, taken together, comprise perhaps the mathematically ablest group of junior high school age to be studied as such. It is not unreasonable to assume that there is great potential for achievement and productivity in this group. This is especially true since the essential motivation may be inferred to be present from their scores on tests far above their grade level--obtaining such high scores indicates interest in and previous work on the subject.

The question of creativity, however, is above and beyond any consideration of academic achievement or even eventual scientific or mathematical productivity. The identification of a verified high-ability, highly motivated group at a young age (12-14), which will be followed longitudinally, affords the opportunity of observing the development of creativity and of assessing the methods of assessment. (This presumes that some of the students will prove to be more creative than others at some future time--a safe assumption if there is something more to creativity than purely cognitive factors). Accordingly, the diverse methods listed below were used to rate the "creative potential" of the individuals in this group.

Method

Subjects

The subjects in this study were junior high school students who were the top scorers in two mathematics competitions held one year apart.

To be eligible for the competition the student had to be in the seventh or the eighth grade, or less than 14 years old if in a higher grade. The top 35 scorers of 396 contestants in the first competition were invited back for further testing, as were the top 44 scorers of 953 contestants in the second competition. Of the top 79 students who were invited back, 76 accepted the invitation.

Only four girls qualified for an invitation to be retested, and all accepted. The small number makes an analysis by sex impossible, however, and they have been dropped from the subject pool, leaving 72 boys for the analysis. A discussion of the sex difference in these data by Astin (in press) is of interest.

The students were administered the various paper and pencil measures described below at several retesting sessions. Not all of the students have taken all of the measures, and thus the appropriate N's are indicated for each measure. There were 57 of the 72 boys who did take all of the measures, and this group is used as the base group. Means on each measure for those not in the base group were calculated, and no significant differences were found between the base group and non-base group scores. Thus the base group may be considered representative of the total group.

Measures

The Allport-Vernon-Lindzey Study of Values (SV-1970) has often been used in studies of creative artists and scientists. The "classic" value structure of the creative scientist, as reported by MacKinnon (1962) is high theoretical (T), high aesthetic (A). Although an empirical finding, the pattern makes psychological sense in terms of the SV value structure. The T person is concerned primarily with the seeking of knowledge, a

"truth" value, and the relation of this to scientific creativity is obvious. It seems intuitively that the A value is opposed to T; its basis is in an appreciation of beauty, form, and harmony. The paradox is resolved when one recalls the importance of form and harmony to the "elegant" solution in mathematics or the parsimonious scientific theory.

It has often been asserted that the best predictor of future performance is past performance. In terms of research on creativity, it does seem that the most consistently successful method of discriminating creative from less creative groups has been reported past behavior and self-ratings (Taylor & Holland, 1962). A lengthy and fairly well-normed instrument of this type is the Biographical Inventory -Creativity (BIC--Schaefer, 1970), which yields scores on "art and writing" and "mathematics and science."

Barron & Welsh (1952) proposed that preference for certain figures may be related to a "style" factor which may in turn have a bearing upon creativity. Creative artists tended to like more complex and asymmetrical shapes than non-artists. Although the results of extensive research with the Barron-Welsh Art Scale (BWAS) have been inconclusive (Baird, 1972), some promising possibilities are offered in the use of the BWAS.

Another method for predicting creativity which has often been used is the determination of consistent personality dimensions or traits among creative people (e.g., Cattell & Drevdahl, 1955; Hall & MacKinnon, 1969). The California Psychological Inventory (CPI--Gough, 1957, 1969) was administered to nearly all the individuals in the group. Hall and

MacKinnon (1969) have published a regression equation for the prediction of creativity using the CPI scales.

Vocational interest inventories have also been administered to this group. Although they fall low on a preliminary rank of predictors of creativity (Taylor & Holland, 1962), their stability over time may prove important in a longitudinal study. The instruments which have been used are: the Strong-Campbell Interest Inventory (SCII), which is the most recent and still experimental revision of the Strong Vocational Interest Blank (SVIB), and which unites the men's and women's forms (Campbell, personal communication); and the "Occupations" checklist, page 8 from Holland's Self-Directed Search (Holland, 1970).

It should be noted that a series of tests of "creativity" which have not been administered are those which attempt to assess "divergent thinking" and "convergent thinking." There are several reasons for this omission. The first is that the tests which appear factorially to assess this aspect of thinking have low predictive validity. Second, the BWAS seems to be related to this same distinction (Baird, 1972). Third, there is some confounding in that "divergent thinking" seems to be more important for artistic creativity than scientific creativity.

Another method which has been often used is the assessment of "Ideational fluency" (Wallach, 1971). No direct assessment of this is planned, for several reasons. Wallach (1971) argues that an accurate account of the "ideational fluency" of an individual can be obtained only in a warm and permissive setting, and that the process is quite long. Additionally, the reliability estimates of such assessments are not high.

In addition to the above listed measures, one further evaluation of the "creative potential" of these students will be made. It rests on the idea of a "minimum IQ" level for creative attainment (e.g., Cattell & Butcher, 1968). Accordingly, scores on Raven's Advanced Progressive Matrices (APM) are analyzed to assess "sufficiency" of non-verbal reasoning ability.

Results

The "Study of Values" (SV)

The typical value pattern of creative scientists (MacKinnon, 1962) is high theoretical (T), high aesthetic (A). This group of mathematically precocious boys clearly shows the high T scores on the SV. Table 1 lists the values and their frequency of occurrence as highest,

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Insert Table 1 about here

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second highest, or lowest. Of the 72 S's, 42, or 58%, had it as their highest value. An additional 13.5 (with ties counting .5), or 19%, had it as their second highest value. Thus 52.5, or 77% overall, had T as their first or second highest value. It is not surprising that these students, who participated in a mathematics competition, would show as a high value an interest in learning per se.

These students are not as high on A as they are on T. Only 3.5, or 5%, have it as their highest value; an additional 2, or 3%, have it as their second highest value. Thus only 6.5 students overall, or 8%, have it as their first or second highest value. This absence of an aesthetic orientation could be rationalized post hoc, by ascribing it

to the youthfulness of the group or to other causes, but it is disconcerting nonetheless. The college experience, however, which may be helpful in the development of an aesthetic orientation (Huntley, 1965), still lies ahead for this group.

Vocational Interest Inventories

On Holland's (1970) "Occupations" checklist from the Self Directed Search, there are six categories of occupations with 14 specific occupations in each. The categories are: realistic (R); conventional (C); investigative (I); social (S); artistic (A); and enterprising (E). An individual's most preferred category is determined as the one with the most occupations checked.

As anticipated, the category most frequently checked as highest was I, investigative. Most of the occupations in that category are science oriented, and typically require advanced educational degrees. Of this academically motivated, math-science oriented group, 46, or 61%, had I as their most preferred category (or was tied with another category as most preferred). An additional 18, or 24%, had it as their second value. A total of 85% of the group, therefore, had I in the top two preferred categories. Although not directly related to creativity, it seems more than likely that if one is to be a creative scientist or mathematician a preference for I occupations is desirable, perhaps even necessary.

This preference for investigative occupations is borne out by an analysis of the S's scores on the Strong-Campbell Interest Inventory (SCII). The SCII gives scores on the six Holland categories as well as more specific occupational preference information. On the SCII, which not all of the students have taken, 78% of those who have taken it had

I as the highest score. Fifteen percent more had it as the second highest score. Thus, 93% overall had I as the first or second highest category.

The Biographical Inventory

Scores on the Biographical Inventory-Creativity (BIC) are separated into two scales, which for males are "Art and Writing" (AW) and "Mathematics and Science" (MS). The MS score is of more importance for this group, but the AW scores have also been analyzed. Mean scores for both BIC scales are listed in Table 2.

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Insert Table 2 about here

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Some of the items on the BIC are inappropriate for this age group. Several questions, for example, refer to accomplishments and awards during high school, since the instrument was designed for and normed on a college population (Schaefer, 1970). Thus it is likely that the scores of these students on the BIC would increase over time.

But even in comparison with a college norm group, the mathematically precocious students fare well. On the AW scale, the mean score of this group is equivalent to about the 58th %ile of the college males. On the MS scale, their mean score falls at the 68th %ile. In terms of biographical background, then, this group appears to be quite creative. The BIC administered at this age may even underestimate their creative potential.

The California Psychological Inventory

At first glance, this would appear to be a quite uncreative group

on the basis of personality inventory scores. Hall MacKinnon (1969) developed a regression equation using CPI scales which separated more creative from less creative architects. Using that regression equation, this group appears less creative than a group of randomly selected eighth graders as well as a high school norm group (Weiss, Haier, and Keating, in press).

But the deficiency is more apparent than real. The most heavily weighted scale in the Hall & MacKinnon (1969) equation is Achievement via Conformance (AC), which gets a negative weight in distinguishing between more and less creative architects. This would seem to be inappropriate at this age, since the randomly selected groups are clearly less achievement oriented on most dimensions.

This also points up the difficulty of analyzing adolescent personality structure and comparing it to adult norms. Not only do the scale scores change considerably over time, but the personality of a creative adult may have been quite different when that adult was an adolescent (Parloff, 1966).

The Barron-Welsh Art Scale (BWAS)

The BWAS has been used to discriminate between creative artists and the general population (Barron & Welsh, 1952), and in other studies of creativity. Although the way in which this type of "artistic perception" develops over time is not known, some idea of the creativity of this group may be gathered from this instrument. It is additionally confounded, however, in that a preference for asymmetry over symmetry, for example, may not mark the creative scientist or mathematician.

As a group, the mathematically precocious boys do not appear to be especially creative when compared with the general population. The

mean of the /male non-artist group reported by Welsh (1959) is 15.06 (of a possible 62). The mean of these students is 17.91 (see Table 2), a non-significant difference. / Thus as a group these students appear to be more like the general population than artists.

The Advanced Progressive Matrices

MacKinnon (1962) reported that in most fields there is no correlation between intelligence and creativity, although within these areas where one can be creative there are rarely individuals of low intelligence. Among mathematicians, however, a low positive correlation between intelligence and creativity is observed.

As one can readily see from Table 2, this group has little difficulty in meeting a "minimum intelligence" criterion. This is not surprising, given the method of selection of the group. The mean of the group, 29, is above the 95th percentile of adult norms (Raven, 1965). All but 5 of the 72 boys score at least one standard deviation above the mean for university students.

The High Creatives

From the foregoing analysis it is not clear whether as a group these mathematically precocious boys should be considered "creative" or not. The BIC indicates that they are, but the CPI results suggest that they are not, and the BWAS characterizes them as most like the "general population" in artistic perception. But the proper objection is raised that it is not a group but rather an individual who is creative. "As regards intellectual work it remains a fact, indeed, that great decisions in the realm of thought and momentous discoveries and solutions to problems are only possible to an individual working in solitude."

(Freud, 1960 [1921], p.20)

If this is the case, then the important question revolves around which of the individuals within this group are likely to be creative. To discern this it is necessary to look at those individuals who score above a reasonable criterion on each of the measures and then at those who score at or above the criterion on more than one measure. This is especially applicable since the measures are uncorrelated within this group (see Table 3).

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Insert Table 3 about here

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The criterion which was used was the mean score of the group plus one standard deviation. To check on the possibility that this might be an uncreative group, thus invalidating within group comparisons, the same criterion was applied using relevant norm group means and standard deviations. Table 4 gives the number of students who scored above the

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Insert Table 4 about here

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criterion, on both within group and norm group comparisons, for each instrument. If each of these instruments does measure some aspect of creative potential, then a number of individuals in this group would seem to have such potential.

Those students, however, who score above the criterion on more than one measure should be the ones considered to have the most creative potential. In Table 5 are listed the numbers of individuals who

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scored above the criterion, for both within group and norm group comparisons, on at least one measure, on any two or more measures, on any three or more, and on four or more. As one can readily see, the number who score above the criteria of two or more measures on norm group comparisons is still a sizable group, and 10 students, or nearly 14% of the total group. meet the criteria on three or more measures. Thus if each of these tests do indeed measure some aspect of creative potential, the outlook for a good minority of the group is quite bright.

Discussion

The measurement of creativity has posed problems to psychological and educational researchers for years. Part of the problem is due to conceptual confusion between a domain of creativity or creative thinking analagous to that of intelligence (Thorndike, 1972) and an analysis of highly creative individuals to discover the characteristics of the creative person (MacKinnon, 1962). The availability of various methods which have been developed to detect one or the other type of creativity and the lack of agreement among them require an eclectic approach.

From the use with this group of mathematically precocious boys of several different types of measures which have been held to assess some dimension of creativity, it appears that the creative potential of this group is quite high. Although as a group they do not stand out from the norm groups on any measures except the APM, where they are much above the mean for university students, and on BICMS, where they are slightly above the mean for college students, a number of individuals

within the group are far above the mean on three or four of the five measures used (see Table 5).

There is a strong theoretical-investigative orientation of the group, and to the extent that this is important for creativity in mathematics and science, there is little difficulty for anyone in the group. If, however, the aesthetic orientation is important, a large segment of the group may have some difficulty. This is mitigated somewhat by the expectation that this aesthetic orientation will grow during the college experience.

Some of the students who at this time using these measures do not appear to be particularly creative may in the future come up to the criteria which were used in this investigation. Developmental data on the BWAS is scant, but it seems reasonable that scores of these students on the BIC and the CPI creativity regression equation will increase over time.

There are at least two possible explanations for the lack of agreement of the measures of creativity in this group. First, one or more of the measures used may not bear any deep relationship to creativity. They may not be measuring what they purport to measure, i.e., they may be invalid as measures of creativity. The second possibility is that there is a problem of restriction of range within this group. Since they are homogeneous to a large extent on cognitive measures (although not as much as one might expect -- Keating, in press), the possibility of too little variation on measures that are even slightly correlated with the selection measure is acute.

A third possibility is more intriguing. It may be that each of the measures does bear some relationship to creativity, and that each

of them is measuring a different aspect of creativity. If they are valid measures, the fact that they are uncorrelated would strongly suggest such a possibility. Creativity, as used to describe the highly creative individual, would have to be viewed not as a unitary construct, but rather as a situation toward which a great many factors must contribute. A longitudinal follow-up of this large group of mathematically talented youngsters, which is planned, should provide some answers to these questions.

In conclusion, the third possibility discussed above suggests a "synergetic" theory of creativity. Many factors and influences contribute to the development of the highly creative individual, and all or nearly all of them must contribute positively for the individual to be truly creative. If but a few of the factors are negative or even neutral, the individual may be routinely productive or erratically unproductive, but not truly creative. Such an explanation would account not only for the lack of correlation among valid measures of creativity, but also for the observed rarity of truly creative individuals.

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Footnote

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Table 1

Frequency of Occurrence of the Six SV[1] Values as Highest, Second Highest, or Lowest as Percent of Total

	Theoretical	Aesthetic	Social	Political	Economic	Religious
1st Highest	58	5	8	14	8	7
2nd Highest	19	3	10	38	24	6
Lowest (6th)	0	31	10	4	12	43

[1]Allport-Varnon-Lindzey Study of Values

Table 2

Mean Scores of Mathematically Precocious Boys on Five Measures Related to Creativity

Measure	N	Mean	S.D.
BIC - AW [1]	58	100.66	8.49
BIC - MS [2]	58	106.53	4.76
CPI [3]	67	11.21	4.48
BWAS [4]	64	17.91	11.91
APM [5]	69	29.51	3.08

Notes:

[1] Biographical Inventory of Creativity, Arts & Writing

[2] Biographical Inventory of Creativity, Mathematics & Science

[3] California Psychological Inventory, Creativity regression equation from Hall & MacKinnon (1969)

[4] Barron-Welsh Art Scale

[5] Raven's Advanced Progressive Matrices

Table 3

Correlation Matrix of Five Measures Related to Creativity for 57 Mathematically Precocious Boys

	BIC - AW[1]	BIC - MS	CPI	BWAS	APM
BIC - AW	1	.611*	.051	.251	-.184
BIC - MS		1	-.121	.249	.003
CPI			1	-.111	.001
BWAS				1	.064
APM					1

[1] For abbreviations of measures, see Table 2.

* $p < .01$

Table 4

Number of Students at or Above Criterion[1], Within Group and Norm Group Comparisons

	Measures				
	BICAW[2]	BICMS	CPI	BWAS	APM
Within Group (WG) Criterion	109	111	15.92	30	33
Students Above WG Criterion	12	10	11	12	14
Norm Group[3] (NG) Criterion	109	109	19.94	26	25
Students Above NG Criterion	12	17	1	19	64

[1]Criterion = $\bar{X} + 1\sigma$

[2]See Table 2 for abbreviations.

[3]Norm groups as follows: BICAW and BICMS -- college males (Schaefer, 1970)

CPI -- eighth grade male norm group (Lessinger & Martinson, 1961)

BWAS -- non-artists (general population -- Welsh, 1959)

APM -- University students (Raven, 1965)

Table 5

Students Above Within Group or Norm Group Criteria[1] on One or More Creativity Related Measures

	Students Above Criterion				
	On 1 or more measures	On 2 or more measures	On 3 or more measures	On 4 or more measures	On 5 measures
Within Group Comparison	39	16	3	1	0
Norm Group Comparison	68	36	10	3	0

[1]For measures and criteria, see Table 4