CREATIVITY¹

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DISCUSS the subject of creativity with considerable hesitation, for it represents an area in L which psychologists generally, whether they be angels or not, have feared to tread. It has been one of my long-standing ambitions, however, to undertake an investigation of creativity. Circumstances have just recently made possible the realization of that ambition.² But the work has been started only within the past year. Consequently, if you are expecting answers based upon new empirical research you will be disappointed. What I can do at this time is to describe the plans for that research and to report the results of considerable thinking, including the hypotheses at which my students and I have arrived after a survey of the field and its problems. The research design, although not essentially new, should be of some interest. I will also point out some implications of the problems of creativity in vocational and educational practices.

SOME DEFINITIONS AND QUESTIONS

In its narrow sense, creativity refers to the abilities that are most characteristic of creative people. Creative abilities determine whether the individual has the power to exhibit creative behavior to a noteworthy degree. Whether or not the individual who has the requisite abilities will actually produce results of a creative nature will depend upon his motivational and temperamental traits. To the psychologist, the problem is as broad as the qualities that contribute significantly to creative productivity. In other words, the psychologist's problem is that of creative personality.

In defining personality, as well as other concepts preparatory to an investigation, definitions of an operational type are much to be preferred. I have often defined an individual's personality as his unique pattern of traits. A trait is any relatively enduring way in which persons differ from one another. The psychologist is particularly interested in those traits that are manifested in performance; in other words, in behavior traits. Behavior traits come under the broad categories of aptitudes, interests, attitudes, and temperamental qualities. By aptitude we ordinarily mean a person's readiness to learn to do certain types of things. There is no necessary implication in this statement as to the source of the degree of readiness. It could be brought about through hereditary determination or through environmental determination; usually, if not always, by an interaction of the two. By interest we usually mean the person's inclination or urge to engage in some type of activity. By attitude we mean his tendency to favor or not to favor (as shown objectively by approach-withdrawal behavior) some type of object or situation. Temperamental qualities describe a person's general emotional disposition: for example, his optimism, his moodiness, his self-confidence, or his nervousness.

Creative personality is then a matter of those patterns of traits that are characteristic of creative persons. A creative pattern is manifest in creative behavior, which includes such activities as inventing, designing, contriving, composing, and planning. People who exhibit these types of behavior to a marked degree are recognized as being creative.

There are certain aspects of creative genius that have aroused questions in the minds of those who have reflected much about the matter. Why is creative productivity a relatively infrequent phenomenon? Of all the people who have lived in historical times, it has been estimated that only about two in a million have become really distinguished (5). Why do so many geniuses spring from parents who are themselves very far from distinguished? Why is there so little apparent correlation between education and creative productiveness? Why do we not produce a larger number of creative geniuses than we do, under supposedly enlightened, modern educational practices? These are serious questions for thought and

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 $^{^{2}}$ A research project on the aptitudes of high-level personnel, supported by the Office of Naval Research.

investigation. The more immediate and more explorable problem is a double one: (1) How can we discover creative promise in our children and our youth? and (2) How can we promote the development of creative personalities?

NEGLECT OF THE STUDY OF CREATIVITY

The neglect of this subject by psychologists is appalling. The evidences of neglect are so obvious that I need not give proof. But the extent of the neglect I had not realized until recently. To obtain a more tangible idea of the situation, I examined the index of the Psychological Abstracts for each vear since its origin. Of approximately 121,000 titles listed in the past 23 years, only 186 were indexed as definitely bearing on the subject of creativity. The topics under which such references are listed include creativity, imagination, originality, thinking, and tests in these areas. In other words, less than two-tenths of one per cent of the books and articles indexed in the Abstracts for approximately the past quarter century bear directly on this subject. Few of these advance our understanding or control of creative activity very much. Of the large number of textbooks on general psychology, only two have devoted separate chapters to the subject during the same period.

Hutchinson, reviewing the publications on the process of creative thinking to the year 1931, concluded that the subject had hardly been touched by anyone (7). Markey, reviewing the subject of imagination four years later, reported very little more in the way of a fundamental contribution to the subject (9).

Some of you will undoubtedly feel that the subject of creative genius has not been as badly neglected as I have indicated, because of the common belief that genius is largely a matter of intelligence and the IQ. Certainly, that subject has not been neglected. But, for reasons which will be developed later, I believe that creativity and creative productivity extend well beyond the domain of intelligence.

Another important reason for the neglect, of course, is the difficulty of the problems themselves. A practical criterion of creativity is difficult to establish because creative acts of an unquestioned order of excellence are extremely rare. In this respect, the situation is much like that of a criterion for accident proneness which calls for the actual occurrence of accidents. The accidental nature of many discoveries and inventions is well recognized. This is partly due to the inequality of stimulus or opportunity, which is largely a function of the environment rather than of individuals. But if environmental occasions were equal, there would still be great differences in creative productivity among individuals.

There are, however, greater possibilities of observing individual differences in creative performance if we revise our standards, accepting examples of lower degrees of distinction. Such instances are more numerous. But even if we can detect and accept as creative certain acts of lower degrees of excellence, there are other difficulties. Creative people differ considerably in performance from time to time. Some writers on the subject even speak of rhythms of creativity. This means that any criterion, and probably any tests of creativity as well, would show considerable error variance due to function fluctuation. Reliabilities of tests of creative abilities and of creative criteria will probably be generally low. There are ways of meeting such difficulties, however. We should not permit them to force us to keep foot outside the domain.

Another reason for the oversight of problems of creativity is a methodological one. Tests designed to measure intelligence have fallen into certain stereotyped patterns, under the demands for objectivity and for scoring convenience. I do not now see how some of the creative abilities, at least. can be measured by means of anything but completion tests of some kind. To provide the creator with the finished product, as in a multiple-choice item, may prevent him from showing precisely what we want him to show: his own creation. I am not opposed to the use of the multiple-choice or other objectively scorable types of test items in their proper places. What I am saying is that the quest for easily objectifiable testing and scoring has directed us away from the attempt to measure some of the most precious qualities of individuals and hence to ignore those qualities.

Still another reason for the neglect of the problems of creativity is to be found in certain emphases we have given to the investigations of learning. For one thing, much learning research has been done with lower animals in which signs of creativity are almost nonexistent. For another thing, learning theory has been generally formulated to cover those phenomena that are easiest to order in logical schema. Learning theorists have had considerable difficulty with the behavior known as insight, to which creative behavior shows much apparent relationship (15). It is proper to say that a creative act is an instance of learning, for it represents a change in behavior that is due to stimulation and/or response. A comprehensive learning theory must take into account both insight and creative activity.

THE SOCIAL IMPORTANCE OF CREATIVITY

There is general recognition, on the part of those outside the academic fold, at least, of the importance of the quest for knowledge about creative disposition. I can cite recent evidences of the general interest in the discovery and development of creative talent. Large industries that employ many research scientists and engineers have held serious meetings and have had symposia written about the subject (9). There is much questioning into the reasons why graduates from the same institutions of higher learning, with high scholastic records and with strong recommendations, differ so widely in output of new ideas. The enormous economic value of new ideas is generally recognized. One scientist or engineer discovers a new principle or develops a new process that revolutionizes an industry, while dozens of others merely do a passable job on the routine tasks assigned to them.

Various branches of the government, as you all know, are now among the largest employers of scientific and technical personnel. These employers, also, are asking how to recognize the individuals who have inventive potentialities. The most common complaint I have heard concerning our college graduates in these positions is that while they can do assigned tasks with a show of mastery of the techniques they have learned, they are much too helpless when called upon to solve a problem where new paths are demanded.

Both industry and governmental agencies are also looking for leaders. Men of good judgment, planning ability, and inspiring vision are in great demand. How can leaders with imagination and vision be discovered? Can such qualities be developed? If those qualities can be promoted by educational procedures, what are those procedures?

We hear much these days about the remarkable new thinking machines. We are told that these machines can be made to take over much of men's thinking and that the routine thinking of many industries will eventually be done without the employment of human brains. We are told that this will entail an industrial revolution that will pale into insignificance the first industrial revolution. The first one made man's muscles relatively useless; the second one is expected to make man's brain also relatively useless. There are several implications in these possibilities that bear upon the importance of creative thinking. In the first place, it would be necessary to develop an economic order in which sufficient employment and wage earning would still be available. This would require creative thinking of an unusual order and speed. In the second place, eventually about the only economic value of brains left would be in the creative thinking of which they are capable. Presumably, there would still be need for human brains to operate the machines and to invent better ones.

SOME GENERAL THEORIES OF THE NATURE OF CREATIVITY

It is probably only a layman's idea that the creative person is peculiarly gifted with a certain quality that ordinary people do not have. This conception can be dismissed by psychologists, very likely by common consent. The general psychological conviction seems to be that all individuals possess to some degree all abilities, except for the occurrence of pathologies. Creative acts can therefore be expected, no matter how feeble or how infrequent, of almost all individuals. The important consideration here is the concept of continuity. Whatever the nature of creative talent may be, those persons who are recognized as creative merely have more of what all of us have. It is this principle of continuity that makes possible the investigation of creativity in people who are not necessarily distinguished.

The conception that creativity is bound up with intelligence has many followers among psychologists. Creative acts are expected from those of high IQ and not expected from those of low IQ. The term "genius," which was developed to describe people who distinguish themselves because of creative productivity, has been adopted to describe the child with exceptionally high IQ. Many regard this as unfortunate, but the custom seems to have prevailed.

There is much evidence of substantial, positive correlations between IQ as measured by an intelligence test and certain creative talents, but the extent of the correlations is unknown. The

work of Terman and his associates is the best source of evidence of these correlations; and vet. this evidence is not decisive. Although it was found that distinguished men of history generally had high estimated IO's, it is not certain that indicators in the form of creative behavior have not entered into those estimations (2). It would be much more crucial to know what the same individuals would have done on intelligence tests when they were children. Terman's study of the thousand children of exceptionally high IO's who have now reached maturity does not throw much light on this theory. Among the group there is plenty of indication of superior educational attainment and of superior vocational and social adjustment. On the other hand, there seems to be as yet little promise of a Darwin, an Edison, or a Eugene O'Neill, although the members of the group have reached the age level that has come to be recognized as the "most creative years." The writers on that study recognize this fact and account for it on the basis of the extreme rarity of individuals of the calibre of those whom I have mentioned (11). It is hoped that further followup studies will give due attention to criteria of a more specifically creative character.

When we look into the nature of intelligence tests, we encounter many doubts concerning their coverage of creative abilities. It should be remembered that from the time of Binet to the present, the chief practical criterion used in the validation of tests of intellect has been achievement in school. For children, this has meant largely achievement in reading and arithmetic. This fact has generally determined the nature of our intelligence tests. Operationally, then, intelligence has been the ability (or complex of abilities) to master reading and arithmetic and similar subjects. These subjects are not conspicuously demanding of creative talent.

Examination of the content of intelligence tests reveals very little that is of an obviously creative nature. Binet did include a few items of this character in his scale because he regarded creative imagination as one of the important higher mental functions that should be included. Revisions of the Binet scale have retained such items, but they represent only a small minority. Group tests of intelligence have generally omitted such items entirely.

The third general theory about creativity is, in fact, a theory of the entire personality, *including*

intelligence. I have defined personality as a unique pattern of traits, and traits as a matter of individual differences. There are thousands of observable traits. The scientific urge for rational order and for economy in the description of persons directs us to look for a small number of descriptive categories. In describing mental abilities, this economy drive has been grossly overdone when we limit ourselves to the single concept of intelligence. Furthermore, the term "intelligence" has by no means achieved logical or operational invariance and so does not satisfy the demand for rational order.

We do not need the thousands of descriptive terms because they are much interrelated, both positively and negatively. By intercorrelation procedures it is possible to determine the threads of consistency that run throughout the categories describing abilities, interests, and temperament variables. I am, of course, referring to the factorial conception of personality. From this point of view, personality is conceived geometrically as a hypersphere of n dimensions, each dimension being a dependable, convenient reference variable or concept. If the idea of applying this type of description to a living, breathing individual is distasteful, remember that this geometric picture is merely a conceptual model designed to encompass the multitude of observable facts, and to do it in a rational, communicable, and economical manner.

With this frame of reference, many of the findings and issues become clarified. The reason that different intelligence tests do not intercorrelate perfectly, even when errors of measurement have been taken into account, is that each test emphasizes a different pattern of primary abilities. If the correlations between intelligence-test scores and many types of creative performance are only moderate or low, and I predict that such correlations will be found, it is because the primary abilities represented in those tests are not all important for creative behavior. It is also because some of the primary abilities important for creative behavior are not represented in the test at all. It is probably safe to say that the typical intelligence test measures to a significant degree not more than a halfdozen of the intellectual factors (8). There are surely more intellectual factors than that. Some of the abilities contributing to creative success are probably non-intellectual; for example, some of them are perceptual. Probably, some of the factors most crucial to creative performance have not

yet been discovered in any type of test. In other words, we must look well beyond the boundaries of the IQ if we are to fathom the domain of creativity.

DEVELOPMENT OF CREATIVITY

Before referring to the experimental design and to more specific hypotheses concerning the nature of creativity, I will venture one or two opinions on the general problem of the development of creativity. For I believe that much can be done to encourage its development. This development might be in the nature of actual strengthening of the functions involved or it might mean the better utilization of what resources the individual possesses, or both. In any case, a knowledge of the functions is important.

We frequently hear the charge that under presentday mass-education methods, the development of creative personality is seriously discouraged. The child is under pressure to conform for the sake of economy and for the sake of satisfying prescribed standards. We are told by the philosophers who have given thought to the problem that the unfolding of a creative personality is a highly individual matter which stresses uniqueness and shuns conformity. Actually, the unfolding of the individual along the lines of his own inclinations is generally frowned upon. We are told, also, that the emphasis upon the memorizing of facts sets the wrong kind of goal for the student. How serious these charges are no one actually knows. We have very little experimental evidence that is decisive one way or the other and such evidence is hard to obtain.

Charles Kettering one time commented upon a survey in which it was found that a person with engineering or scientific training had only half the probability of making an invention compared with others. His comment was that an inventor should be defined as "a fellow who doesn't take his education too seriously" (9). If the results of that survey represent the actual situation, either creative individuals do not seek higher education in engineering and science, or that kind of education has negative transfer effects with respect to inventive-ness.

Many of us teachers assert that it is our main objective to teach students how to think, and this means also to think constructively. Certainly, if we succeeded in this objective, there should be much evidence of creativeness in the end product. I am convinced that we do teach some students to think, but I sometimes marvel that we do as well as we do. In the first place, we have only vague ideas as to the nature of thinking. We have little actual knowledge of what specific steps should be taken in order to teach students to think. Our methods are shotgun methods, just as our intelligence tests have been shotgun tests. It is time that we discarded shotguns in favor of rifles.

We all know teachers who pride themselves on teaching students to think and yet who give examinations that are almost entirely a matter of knowledge of facts. Please do not misunderstand me. I have a strong appreciation of knowledge of facts. No creative person can get along without previous experiences or facts; he never creates in a vacuum or with a vacuum. There is a definite place for the learning of facts in our educational system. But let us keep our educational objectives straight. Let us recognize where facts are important and where they are not. Let us remember, too, that the kinds of examinations we give really set the objectives for the students, no matter what objectives we may have stated.

The confusion of objectives is illustrated by the following incident. The story was told by a former dean of a leading Midwestern University. An old, experienced teacher and scholar said that he tried to encourage originality in his students. In a graduate course, he told the class that the term paper would be graded in terms of the amount of originality shown. One school teacher in the class was especially concerned about getting a high mark She took verbatim notes, conin the course. tinuously and assiduously, of what the learned professor said in class. Her term paper, the story goes, was essentially a stringing together of her transcribed lecture notes, in which the professor's pet ideas were given prominent place. It is reported that the professor read the term papers himself. When the school teacher's paper was returned, the professor's mark was an A, with the added comment, "This is one of the most original papers I have ever read."

Before we make substantial improvement in teaching students to think, in my opinion we will have to make some changes in our conceptions of the process of learning. The ancient faculty psychology taught that mental faculties grow strong by virtue of the exercise of those faculties. We all know from the many experiments on practice in memorizing that exercises in memorizing are not necessarily followed by improvement of memory in general. We all know that exercises in perceptual discriminations of certain kinds are not followed by improvement of perceptual discriminations in general (13). Thorndike and others concluded that the study of courses in high-school curricula did not necessarily result in a general improvement in intellect, but that the increases in test scores could be attributed to learning of a more specific nature (1, 12). Following this series of experiments the conclusion has often been that learning consists of the development of specific habits and that only very similar skills will be affected favorably by the learning process.

In view of the newer findings concerning primary abilities, the problems of formal discipline take on new meaning, and many of the experiments on the transfer of training will have to be reexamined and perhaps repeated with revised conditions. The experiments just cited do justify the rejection of the concepts of a general memory power, a general perceptual-discrimination power, and perhaps, also, rejection of the concept of a single power called intellect. These findings are in harmony with factorial theory. But the other alternative to the idea of formal discipline is not necessarily a theory of specific learning from specific practice.

There is certainly enough evidence of transfer effects. Experiments should be aimed to determine whether the instances of positive, zero, and negative transfer effects conform in a meaningful way to the outlines of the primary abilities. The work of Thorndike and others that I have just cited does, in fact, actually throw some light on this question. Although this aspect of their findings is usually not mentioned, they reported that highschool students' experiences in numerical, verbal, and spatial types of courses—arithmetic and bookkeeping, Latin and French, and manual training were associated with relatively greater gains in numerical, verbal, and spatial types of tests, respectively.

A general theory to be seriously tested is that some primary abilities can be improved with practice of various kinds and that positive transfer effects will be evident in tasks depending upon those abilities. At the present time some experiments of this type are going on in the Chicago schools under the direction of Thelma Gwinn Thurstone (14). In one sense, these investigations have returned to the idea of formal discipline. The new aspect of the disciplinary approach is that the presumed functions that are being "exercised" have been indicated by empirical research.

FACTORIAL RESEARCH DESIGN

The general outline of the design for a factoranalysis investigation is familiar to many of you. It has been described before but needs to be emphasized again (14). The complete design involves a number of steps, not all of which are essential but all of which are highly desirable if the investigator is to make the most efficient use of his time and to achieve results of maximum value. The major steps will be mentioned first, then more details concerning some of them.

One first chooses the domain of his investigation. It may be the domain of memory abilities, visualperceptual abilities, reasoning abilities, or the domain of introversion-extraversion.

One next sets up hypotheses as to the factors he expects to find in that domain. His preparatory task of hypothesis formation goes further. It includes the framing of several alternative hypotheses as to the more precise nature of each factor. This is necessary as the basis for transforming each factor hypothesis into the operational terms of test ideas. He then constructs tests which he thinks will measure individual differences in the kind of ability, or other quality, he thinks the factor to be. He will want to include in the test battery some reference tests that measure already known factors. One reason for this is that the new tests will almost inevitably also measure to some extent factors that have previously been established, such as verbal comprehension, number facility, and visualization. If such variance is probably going to appear in more than one new test in the battery, it is best to have that variance clearly brought out and readily identifiable. Another reason is that it is possible, after all, that one or more of the hypothesized factors will turn out to be identifiable with one or more of the known factors. The possiblity of this identification must be provided for by having the suspected, known factors represented in the battery.

The test battery is administered to a sample of adequate size from a population of appropriate qualifications. Certain kinds of populations are better for bringing out variances in some common factors and other kinds are more suitable for other purposes. There should be relative homogeneity in certain features that might be correlated with the factors, such as sex, age, education, and other conditions. Some thought should be given to whether tests should be speed tests or power tests or something between the two. Some consideration should also be given to the most appropriate type of score for each test.

Factors are extracted and their reference axes are rotated into positions that are compelling because of the nature of the configuration of test vectors in the hyperspace. The psychological nature of each factor is surmised by virtue of the kinds of tests that have substantial variance attributable to that factor in contrast to tests which lack that variance.

In many respects, the complete factor-analysis design has properties parallel to those of a good experiment. In both, we begin with hypotheses. In both, some conditions are held constant while others are varied. In both, the measured outcomes point toward or away from the hypotheses. One important difference is the possibility of a statistical test of significance of the measured result for the experiment but not for the factor analysis. Confidence in the latter case depends upon the compellingness of the factor structure and the repeated verification of a result.

As an illustration of this analogy to an experiment, I will cite the factorial study of the well-known figure-analogies test. In the Army Air Forces research results, the figure-analogies test exhibited variances in three factors denoted as reasoning I, II, and III (6). They were thus designated because they were peculiar to a number of reasoning tests, but their more precise natures were obscure. Examination of what one does in solving a figureanalogies item suggests several possible psychological functions or activities. First, one has to grasp correctly the relation between figure one and figure two. This suggests an ability to see a relationship between two objects. Second, one must observe the properties of the third figure. Then, one has to see what kind of a fourth figure it takes to satisfy the same relationship between figure three and figure four. Having decided upon the kind of figure needed, one has to find it among four or five that are supplied in the multiple-choice item. This is a kind of classifying act. There is still another possibility. The mislead responses may be so reasonable that considerable discrimination may be needed to select the best figure for the purpose. Considering the figure-analogies item from a more holistic point of view, there may be a primary ability involved in seeing that there is an identity of two relationships when the elements related are different. Or, there may be a general reasoning-by-analogy ability. Transposability of relations may be a key function here. Thus, we have several hypotheses as to the functions involved. There could be others. For every one of them we also have the further question as to whether the ability implied is restricted to the visual perception of figures or whether it is more general, extending to word meanings, numbers, and sounds. And if it is general, what are its limits?

To seek answers by factorial methods, one would construct special tests, each limited, if possible, to one kind of act implied by each hypothesis. One would also vary the kind of material in each type of test to explore the scope of generality. The answers to the hypotheses (for each hypothesis is in reality a question) would be to find that the loading for each factor would rise with some of the variations and fall with others as compared to its loading in the traditional figure-analogies test. We would hope to find the changes in factor loadings so marked that we would not feel seriously the lack of t tests or F tests.

The question of the sources of factor hypotheses calls for some comment. In a domain in which there have already been factorial studies, the previous results are always suggestive. This makes it appear that the factorist merely moves from hypotheses to hypotheses. This is quite true. It is a fundamental truth of all scientists, no matter what their methods. Some hypotheses are merely better supported and more generally accepted than others at the time. There is enough uncertainty left in many a hypothesis to invite further investigation. That is what makes science interesting. That is what I think Kettering meant when he stated that the inventor is one who does not take his education (or knowledge) too seriously.

In a personality domain in which there has been little previous illumination of the underlying variables, other sources of hypotheses must be sought. The critical-incident technique of Flanagan would be one useful exploratory approach (4). Incidentally, one might say that this method has been used informally in connection with creative people from the "Eureka" episode of Archimedes down to modern times. The literature includes many descriptions of creative events. It would be more correct to refer to these historical reports as anecdotes, however, rather than critical incidents, since they suffer from most of the weaknesses of anecdotes. Where modern writers have attempted to interpret them psychologically, the interpretations have been quite superficial. They abound with vague concepts such as "genius," "intuition," "imagination," "reflection," and "inspiration," none of which leads univocally to test ideas. In the writings of those who have attempted to give a generalized picture of creative behavior, there is considerable agreement that the complete creative act involves four important steps.

According to this picture, the creator begins with a period of preparation, devoted to an inspection of his problem and a collection of information or material. There follows a period of incubation during which there seems to be little progress in the direction of fulfillment. But, we are told, there *is* activity, only it is mostly unconscious. There eventually comes the big moment of inspiration, with a final, or semi-final, solution, often accompanied by strong emotion. There usually follows a period of evaluation or verification, in which the creator tests the solution or examines the product for its fitness or value. Little or much "touching up" may be done to the product.

Such an analysis is very superficial from the psychological point of view. It is more dramatic than it is suggestive of testable hypotheses. It tells us almost nothing about the mental operations that actually occur. The concepts do not lead directly to test ideas. In attempting to distinguish between persons with different degrees of creative talent, shall we say, for example, that some individuals are better incubators than others? And how would one go about testing for incubating ability? The belief that the process of incubation is carried on in a region of the mind called the unconscious is of no help. It merely chases the problem out of sight and thereby the chaser feels excused from the necessity of continuing the chase further.

It is not incubation itself that we find of great interest. It is the nature of the processes that occur during the latent period of incubation, as well as before it and after it. It is individual differences in the efficiency of those processes that will be found important for identifying the potentially creative. The nature of those processes or functions will have to be inferred from performances of the individuals who have been presented with problems, even though the creator is largely unaware of them.

SPECIFIC HYPOTHESES CONCERNING CREATIVE ABILITIES

The hypotheses that follow concerning the nature of creative thinking have been derived with certain types of creative people in mind: the scientist and the technologist, including the inventor. The consensus of the philosophers seems to have been that creativity is the same wherever you find it. To this idea I do not subscribe. Within the factorial frame of reference there is much room for different types of creative abilities. What it takes to make the inventor, the writer, the artist, and the composer creative may have some factors in common, but there is much room for variation of pattern of abilities. Some of the hypotheses mentioned here may apply also to areas of creative endeavor other than science, technology, and invention, but others may not. Included in the list of primary abilities that may contribute to creative efforts of these special groups are the reasoning factors, but I shall restrict mention here to other possible thinking factors that are more obviously creative in character.

First, there are probably individual differences in a variable that may be called *sensitivity to problems*. How this variation among individuals may come about will not concern us at this time. Whether it is best regarded as an ability or as a temperament trait will not concern us, either. The fact remains that in a certain situation one person will see that several problems exist while another will be oblivious to them.

Two scientists look over a research report. There are generally acceptable conclusions, but there is one minor discrepancy in the results. One scientist attributes the discrepancy to "experimental error." The other feels uneasy about the discrepancy; it piques his curiosity; it challenges him for an explanation. His further thinking about the matter develops into a new research project from which highly important findings result. Such an incident was reported by Flanagan (4); it could be found duplicated many times. There are questions as to the generality of such a variable. Is the supposed sensitivity restricted to a certain kind of situation or a certain kind of problem? Is it a perceptual quality as well as a thought quality? Could it be a general impressionability to the environment? Is it our old friend "curiosity" under a new name? Is it an ability to ask questions? Is it a general inhibition against closure? There may be other hypotheses just as pertinent. Each one suggests possible tests of individual differences.

Examples of possible tests follow. One might present the examinee with a short paragraph of expository material and instruct him to ask as many questions as he can that are suggested by the statements, with relatively liberal time allowed. A large part of the scientist's success depends upon his ability to ask questions, and, of course, to ask the right questions. In another test, one might name common household appliances, such as a toaster, or articles of clothing, such as trousers, and ask the examinee to list things that he thinks are wrong or could be improved. As a perceptual test, one might present pictures of objects or forms that are conventional and regular except for minor irregularities. Can the examinee detect the unusual features or will he overlook them? A third possibility is in the form of what we have called a "frustration test," merely because it is somewhat frustrating to many who have tried it. Contrary to the usual test practice, no task instruction is given: only items, and the very general instruction "do something with each item; whatever you think should be done." Each item is of a different type. One or two examinees have refused to do anything with the test.

There is very likely a *fluency* factor, or there are a number of fluency factors, in creative talent. Not that all creators must work under pressure of time and must produce rapidly or not at all. It is rather that the person who is capable of producing a large number of ideas per unit of time, other things being equal, has a greater chance of having significant ideas. There have been previous results yielding several verbal-fluency factors but I have insufficient time to acknowledge those studies properly here. It is probable that there are a number of fluency factors, nonverbal as well as verbal, yet undiscovered. There is a general problem to be investigated, apart from creativity, whether many of the primary thinking abilities have both a power and a speed aspect somewhat independent of each other. Some work of Davidson and Carroll (3) suggests this in a result with regard to one of the reasoning factors.

One kind of fluency test would consist of asking the examinee to name as many objects as he can in a given time, the objects having some specified property; for example, things round, things red, or things to eat. In another test, the ideas might be more complex, as in naming a list of appropriate titles for a picture or for a short story. Still more demanding and also more restricting would be the task of naming exceptions to a given statement. Fluency of inferences may be tested by providing a hypothetical statement to which the examinee is to state as many consequences or implications as he can in a limited time. The statement might be: A new invention makes it unnecessary for people to eat; what will the consequences be? This type of test has been previously proposed by several investigators.

The creative person has *novel* ideas. The degree of novelty of which the person is capable, or which he habitually exhibits, is pertinent to our study. This can be tested in terms of the frequency of uncommon, yet acceptable, responses to items. The tendency to give remote verbal associations in a word-association test; to give remote similarities in a similies test; and to give connotative synonyms for words, are examples of indications of novelty of ideas in the category of verbal tests.

The individual's *flexibility* of mind, the ease with which he changes set, can possibly be indicated in several ways by means of tests. Although there have been disappointments in the attempt to establish a common factor of this type (6), the concept of flexibility and of its probable opposite, rigidity, will not be downed. In conjunction with some of the fluency tests, there may be opportunities to obtain some indications concerning flexibility. Does the examinee tend to stay in a rut or does he branch out readily into new channels of thought? Tests whose items cannot be correctly answered by adhering to old methods but require new approaches, in opposition to old habits of thinking, would be pertinent here. Certain types of puzzles fit this requirement fairly well, for example, a problem in which the examinee cannot succeed without folding

the paper on which he writes, and the idea of doing so must come from him.

Much creative thinking requires the organizing of ideas into larger, more inclusive patterns. For this reason, we have hypothesized a synthesizing ability. As a counterpart to this, one might well expect an analyzing ability. Symbolic structures must often be broken down before new ones can be built. It is desirable to explore many kinds of both synthesizing and analyzing activities, in both perceptual and conceptual problems, in order to determine the existence of such factors and their numbers and whether they cut across both perceptual and conceptual areas.

From Gestalt psychology comes the idea that there may be a factor involving *reorganization* or *redefinition* of organized wholes (15). Many inventions have been in the nature of a transformation of an existing object into one of different design, function, or use. It may be that this activity involves a combination of flexibility, analysis and synthesis, and that no additional hypothesis of redefinition is really needed, but the possibility must be investigated.

There is a possibility of a dimension of ability that has to do with the degree of *complexity* or of intricacy of conceptual structure of which the individual is capable. How many interrelated ideas can the person manipulate at the same time? The scientist must often keep in mind several variables, conditions, or relationships as he thinks out a problem. Some individuals become confused readily; they can keep only one or two items of structure delineated and properly related. Others have a higher resistance to confusion—a greater span of this type. Such an ability might be identifiable with the hypothesized synthesizing factor, but the study should make possible a separation of the two if the distinction is real.

Creative work that is to be realistic or accepted must be done under some degree of evaluative restraint. Too much restraint, of course, is fatal to the birth of new ideas. The selection of surviving ideas, however, requires some *evaluation*. In this direction there must be a factor or two. The evaluations are conceivably of different kinds, consequently the kinds of possible tests are numerous. In a paragraph of exposition, we may ask the examinee to say whether every underlined statement is best classified as a fact, a definition, or a hypothesis. He will, to be sure, need some preliminary instruction in these distinctions. In another test, we can present him with a stated problem, then ask him which of several items are relevant to its solution and which ones are not. In still another test, we can give a problem and several alternative solutions, all correct. The examinee is to rank the solutions in the order of degree of excellence or fitness.

The hypotheses mentioned, as was stated earlier, refer more specifically to a limited domain of creative thinking more characteristic of the scientist and technologist. Even so, this entails a factorial study of substantial proportions. Similar studies will need to be made in the domains of planning abilities, in order to anticipate abilities more characteristic of the economic, the political, and the military leader. Still other restricted domains will need to be investigated to take care of the writer, the graphic artist, and the musical composer.

The question will inevitably arise, "How do you know your tests are valid?" There are two answers to this question. The first is that the factorial study of the tests is in itself one kind of validation. It will determine which tests measure each factor and to what extent. That is a matter of internal validity or factorial validity. It answers the question, "What does the test measure?" The second answer will be in terms of which factors are related to the creative productivity of people in everyday life. That calls for the correlation of factor measures with practical criteria. I feel very strongly that only after we have determined the promising factors and how to measure them are we justified in taking up the time of creative people with tests. If a certain factor we discover turns out not to be related to creative production, we have made a bad guess, but we will have discovered a new factor that may have some other practical validity. If a certain factor is not related to the criteria of creative productivity, the tests which measure it uniquely will also prove to be invalid for predicting these criteria. It is better to fail in the validation of a single factor measure than to fail in the validation of a half-dozen tests. If we make a study of the practical validity of every creative test we can think of before it is analyzed, we are bound to exert considerable wasted effort of our own and of our examinees. This statement, incidentally, applies to the validation study of any test.

Creative productivity in everyday life is undoubtedly dependent upon primary traits other than abilities. Motivational factors (interests and attitudes) as well as temperament factors must be significant contributors. Hypotheses concerning these factors in connection with creative people might be fruitful starting points for factorial investigations. The design of the research would be much the same as that described for creative abilities.

SUMMARY AND CONCLUSIONS

By way of summary, it can be said that psychologists have seriously neglected the study of the creative aspects of personality. On the other hand, the social importance of the subject is very great. Many believe that creative talent is to be accounted for in terms of high intelligence or IQ. This conception is not only inadequate but has been largely responsible for the lack of progress in the understanding of creative people.

The factorial conception of personality leads to a new way of thinking about creativity and creative productivity. According to this point of view, creativity represents patterns of primary abilities, patterns which can vary with different spheres of creative activity. Each primary ability is a variable along which individuals differ in a continuous manner. Consequently, the nature of these abilities can be studied in people who are not necessarily distinguished for creative reasons. Productivity depends upon other primary traits, including interests, attitudes, and temperamental variables.

It is proposed that a fruitful exploratory approach to the domain of creativity is through a complete application of factor analysis, which would begin with carefully constructed hypotheses concerning the primary abilities and their properties. It is suggested that certain kinds of factors will be found, including sensitivity to problems, ideational fluency, flexibility of set, ideational novelty, synthesizing ability, analyzing ability, reorganizing or redefining ability, span of ideational structure, and evaluating ability. Each one of these hypotheses may be found to refer to more than one factor. Some hypothesized abilities may prove to be identical with others or accounted for in terms of others. At any rate, these hypotheses lead to the construction of tests of quite novel types, which is a promising condition for the discovery of new factors. The relation of such factors to practical criteria of creative performance will need to be established. It is likely that the tests have been aimed in the right direction.

Once the factors have been established as describing the domain of creativity, we have a basis for the means of selecting the individuals with creative potentialities. We also should know enough about the properties of the primary abilities to do something in the way of education to improve them and to increase their utilization. These ends certainly justify our best efforts.

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