RELATING PERSONALITY AND BIOGRAPHICAL FACTORS TO SCIENTIFIC CREATIVITY

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ABSTRACT

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AND BIOGRAPHICAL FACTORS TO
SCIENTIFIC CREATIVITY

By Jack A. Chambers

This study is concerned with the personal traits differentiating highly creative research scientists from less creative ones, of those distinguishing psychologists from chemists, and with those biographical factors in scientists' lives which are important in determining the choice of profession within science, and achievement of creative productivity within the profession.

In order to investigate these areas, a questionnaire was developed covering areas suggested by previous research by Roe, Cattell and Drevdahl, and others. The questionnaire, composed of a Biographical Inventory developed by the investigator, five factors from Cattell and Stice's 16 P. F. Questionnaire, items from Maslow's Security-Insecurity Inventory, and the Initiative Scale from Ghiselli's Self-Description Inventory, was mailed to approximately 740 U. S. male scientists (400 chemists and 340 psychologists). Within each profession one-half was chosen on the basis of having achieved eminence as research scientists, as recognized through membership in the National Academy of Sciences or American Philosophical Society, being starred in American Men of Science, or similar

evidence of national recognition for research. The other half was chosen from the membership lists of the professional societies of the discipline, and each individual in this second group was chosen so as to match an individual in the first group on the bases of age, sex, discipline, amount of education, and opportunity for research. No member of this second group, however, had achieved eminence or had become noted for distinguished research.

Sixty per cent of the forms were returned (438 usable forms). Comparisons were then made between creative and control scientists and psychologists and chemists. From other published results, scientists were compared with the general U. S. adult male population, as well as a male college student sample. Creative scientists, regardless of discipline, were found to be more dominant and to have stronger initiative than the less creative ones. The creative groups also appeared much more strongly motivated toward intellectual success as evidenced both by current research and other professional activities, and by past performance in graduate, undergraduate, and high school.

Some significant differences were also found between psychologists and chemists, although these referred predominantly to factors in the earlier lives of the scientists rather than to personality differences between the groups as mature scientists. In relation to students and the general male population, the scientists were found to be more withdrawn, but also more self-sufficient and resourceful.

RELATING PERSONALITY AND BIOGRAPHICAL FACTORS TO SCIENTIFIC CREATIVITY

By

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Preface

This investigation has been directed towards the problem of scientific creativity. Specifically, it has been designed to throw light on the personal traits that distinguish highly creative research scientists from less creative ones, to investigate those that distinguish social scientists from physical scientists, and to uncover the factors in the lives of scientists which are associated with choice of a particular profession and achievement of creative productivity within it.

It is hoped that studies of scientific creativity, such as this one, will not only have a bearing on the selection of mature research scientists with creative potential, but ultimately will be helpful in identifying creative scientific talent in young students.

Since the topic of concern is a broad one, considerable time has been needed in order to assess the problem adequately. Help has also been needed both financially and professionally from various scientists and scientific agencies. Appreciation for financial assistance first of all, goes to the faculty and staff of the Department of Psychology at Michigan State University for the funds which made the initiation of this project possible. Secondly, profound thanks is given to the Trustees of the James McKeen Cattell Fund for their trust and faith in giving support to this project through a grant which provided for the basic expenses incurred during the period of this study.

Although financial help is always welcome, professional help and stimulation were even more necessary for the satisfactory completion of this project. Thanks here are especially due to the author's guidance committee, Dr. Charles F. Wrigley, Chairman, Dr. B. P. Karon, and Dr. Harold Anderson. Dr. James Karslake, although not on the guidance committee, gave very generously of his time. Dr. Wrigley was especially helpful in encouraging the author to seek financial aid through various agencies, which led to the obtaining of the grant mentioned above.

In addition to the individuals mentioned above, many thanks are due to the staffs of the Chemistry and Psychology Departments, Michigan State University, the Division of Psychological Services of the Lansing Board of Education and the administrative officers of the University of South Florida. Many members of these groups served either as subjects in an initial pilot study or as unpaid professional consultants to the project.

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Chapter I. Historical Orientation

The question of why a relatively few individuals turn out highly creative products, while the vast majority of persons do not contribute anything exceptionally unique or original to society has been of interest to scholars for centuries. It has been only in recent years, however, that systematic attacks have been made upon the problem. Typical of the overall or global approach to the problem of creativity are those papers reported by Anderson (1959), contributed by participants in the Michigan State University seminar on creativity, while studies reported by C. W. Taylor (1956; 1958; 1959) conducted by persons taking part in the University of Utah conferences on identification of scientific talent represent more clearly the approach of studying creativity through intensive investigations of restricted parts of the overall problem.

Area of Concern

This study is concerned primarily with an investigation of scientific creativity, thus following the pattern established by the Utah groups. Specifically it is concerned with the differences in personality and biographical factors between mature scientists who are highly creative research men and those who are much less creative in research.

Landmarks of the Psychological Literature

Within the context of the specific area of concern, the major landmarks of the psychological literature, in chronological order, may now be examined.

Visher's (1948) Study. One of the earlier and better studies giving information relative to biographical factors of creative scientists was done by Visher (1948). His subjects were men starred in American Men of Science from 1903-1943. Visher found these highly creative scientists to have a number of biographical facts in common. Among these were: (a) parents who were between 24 and 35 when the individual was born (about 58 per cent of sample); (b) a father who was a professional person (46 per cent of sample); (c) being the oldest child (41½ per cent of sample); (d) having an early residence in other than a large city (75 per cent of sample); (e) having lived as an adolescent near a college (40 per cent of sample); (f) coming from a family which was either poor or in moderate circumstances (91 per cent of sample); (g) receiving scholarship, fellowship, or financial aid in college (87½ per cent of sample); (h) having one or more relatives who had won "more than local recognition" (50 per cent of sample); (i) having decided upon their life's work prior to entering college (45 per cent of sample).

These finding become more meaningful when compared to general population figures for the years concerned. The U. S. Bureau of the Census (1960) reports, for example, that the most productive child bearing years, at least in relation to the mother, were between ages

20 and 29 for the period concerned, and that for the year 1920 (mid-year of the 40 year period), workers classified as professional, technical, and kindred accounted for approximately five per cent of the total of all gainfully employed persons.

Guilford's Presidential Address. Just two years after Visher published the above study, J. P. Guilford (1950), in his now famous presidential address to the American Psychological Association, outlined his views on creativity and suggested ways of testing various hypotheses in the area. This speech undoubtedly had a significantly stimulating effect upon research in this area, and seems to bear a direct relationship to the systematic attacks made on this problem since then.

Roe's Studies. Probably the most intensive studies done in this area to date followed close on the heels of Guilford's address, and were conducted by Anne Roe (1951a; 1951b; 1953a; 1953b). Roe's work consisted of interviewing and obtaining life history, projective (Rorschach and TAT), and intelligence test data on 64 of the most eminent research men in the United States in the areas of Biology, Physics, Psychology, and Anthropology. She also administered group Rorschachs to a number of university faculty members within the four scientific areas throughout the country.

Roe's major finding was that among her creative subjects was a willingness to work hard and for long hours. In addition to this major finding, however, much of Roe's material proved highly interesting and lends itself well to hypothesis formulation. She found that

her subjects were highly intelligent and that they showed initiative, persistence and independence. In addition, some of her subjects were experiencing emotional problems (she stated that there appeared to be basic insecurities present in many cases of her experimental subjects).

Comparing the groups by discipline, on the basis of the Rorschach the highly creative social scientists used less rational control than did the less distinguished ones; interestingly enough, exactly the opposite situation was found within the biological group. No clear-cut difference was found within the physical scientists. Within the eminent group, the biologists appeared to be the best adjusted.

Another finding differentiating social scientists from other scientists was their interest in personal relations. Although biologists and physicists might have been superficially adequate in social situations, they had little interest in them or in personal relations generally. This difference was found both in the eminent and the control group.

The typical life history was found to be that of a first-born child born to a couple living in the midwest, east or west, the father quite often being a professional person, and the socioeconomic class to which the family belonged usually being the upper middle. The religious influence in the home was quite often Protestant. Learning was emphasized as valuable for its own sake. The ties in the homes of the non-social scientists seemed either weak, or were of a positive sort, with both parents and child accepting each other. The parents

of the social scientists, however, were quite often over-protective and dominating with the result that the children in question rebelled against them.

As the children grew, Roe found that they developed a sense of independence and of being different, or isolated. In the case of the social scientists, this feeling of "difference" was partially due to a feeling of family superiority, although this was not the case with the natural (i.e., biological and physical) scientists. Social scientists further differentiated themselves from the others by beginning to date at a younger age, and by participating generally in more social activities, both as an adolescent and as an adult. The adolescent non-social scientists, on the other hand, were somewhat shy, with intellectual or mechanical interests, usually having one or two companions of similar interests in high school, and not dating until well into college. As adults, too, these individuals still avoid social activities as much as possible.

Common factors in the current lives of the eminent scientists, according to Roe, include a general disinterest in religion, a great deal of intellectual curiosity with resulting enjoyment and satisfaction from their work; and, on the part of the social scientists, feelings of guilt over their rebelliousness toward their parents.

Roe's findings thus supported the earlier study of Visher's in regard to occupation of father and position in family as determined by birth. Unfortunately, however, neither study included a

control group of non-eminent scientists, so that it is not possible to say from these investigations whether the factors are related to creativity in science, high intellectual ability, choice of science as a career, etc.

Van Zelst and Kerr Study (1951). Another study conducted at about the same time as Roe's (1951) initial work was one in which biographical factors and job attitudes were correlated with a product tally criterion (with age held constant) using industrial technical and scientific personnel as subjects (Van Zelst & Kerr, 1951). The results indicated that the highly productive person was: (a) technically competent (held the doctorate degree); (b) wanted competent persons to be assigned responsibility for initiating and conducting research; and (c) advocated considerable freedom in working hours, deadline setting, etc.

Knapp and Goodrich (1952). Concurrently with Roe's early investigations came a general interest in determining the characteristics of undergraduate schools and departments standing high in the production of students ultimately achieving the doctorate in science. This interest led to the study by Knapp and Goodrich (1952), who announced that institutions highest in this regard were generally small schools emphasizing broad intellectual pursuits rather than technical training, social or athletic activities, or maintenance of traditional standards. They were relatively often located in the midwest, and infrequently were affiliated with the Catholic Church. High producing departments were found to maintain severe requirements for the major and a high degree of social interaction (evidenced by an

active departmental club).

Terman's Studies. A few years later a highly interesting monograph was published by Terman (1954) based on a group of 800 gifted males (IQ in the upper one per cent) whose lives he had been following since childhood. This study offers some indirect evidence upon the differences between research and non-research scientists.

The physical and biological research scientists in this group tended to be differentiated from the physical and biological non-research scientists in many of the same ways expressed by the sociability factors found in Roe's (1953b) work. Differences were also found in regard to occupation of father (fathers of research men were more often professionals than fathers of non-research scientists), affection and understanding between father and son (much more between non-research scientists and their fathers than between research scientists and their fathers), and motivation (research men maintained higher grade point averages throughout high school and college, graduated from college at an earlier age, took more graduate training, and achieved higher job success ratings than non-research men).

Studies of Productivity. At this same time a study by Dennis (1954) gave definite support to a positive relationship between productivity and creativity in scientific research. This was later substantiated by Bloom (1956), thus lending considerable support to the widespread practice of evaluating an individual's creativity by counting his published scientific articles or patents (depending

on his scientific discipline), and comparing this output to the average of a comparison group.

Cattell's Studies. During the middle fifties Raymond B. Cattell and his associates at the University of Illinois began systematic studies of creativity using several different methods of attack. In his early investigations he studied living eminent social, physical and biological scientific researchers, teachers, and administrators (Cattell & Drevdahl, 1955) and creative writers and artists (Drevdahl & Cattell, 1958), through the use of the 16 P. F. Questionnaire (Cattell & Stice, 1957). He found that the creative persons tended to be cool, aloof and stiff, emotionally mature, dominant, sober, serious and introspective, having less rigid internal standards than the general population, but being more adventurous, sensitive and imaginative.

Differences were also found between creative researchers on the one hand, and creative administrators and teachers on the other. Essentially, the researchers were more aloof and stiff, withdrawn, independent, self-sufficient and self-confident, etc.

Cattell and Drevdahl also found that the social scientists were more warm and sociable, more dominant, and less sober and serious than the natural scientists.

In a later study using a highly interesting approach, Cattell (1959) studied the past histories of eminent scientists from auto-biographical material. He found these persons to have been withdrawn, dominant, introspective, solemn, etc., and in general, to have

differed from the general population in much the same ways as the living scientists in his earlier studies.

Thus, by combining the results of these three studies it would appear that if pictured on a continuum, the creative social scientists would be closest to the general public in such things as friendliness and warmth or what might generally be regarded as sociability factors. Next would be the creative teachers and administrators in other sciences. Somewhere along this line would fall the creative artists and writers, and at the far end would be the creative research scientists--cold, reserved, introverted, and absorbed in their work.

Cattell pointed out that the next step would be to compare the personality profiles of these creative individuals with those of persons within the vocational discipline, who, having similar training and opportunity had not achieved eminence, bur rather had produced little of value.

Other Centers. In addition to the work of the individuals already mentioned, a number of centers have recently become identified with studies of creativity. Among these are the University of Southern California, where Guilford (C. W. Taylor, 1959) and his associates are studying intellectual traits of high level personnel, the University of California, at which Gough, Barron (C. W. Taylor, 1959) and others have been investigating behaviors of scientists and other high level workers (and where a recent study by Barron (1959) supported Roe's early findings that creative research

scientists show initiative, persistence, and independence, and are willing to work hard and for long hours), and the University of Chicago, at which Morris Stein (Stein & Heinze, 1960) and his associates have been investigating intellectual, personality, and social variables involved in scientific creativity.

Current Study Compared with Others

Turning now from an examination of the outstanding studies previously done in this area to a consideration of the study at hand, it should be noted that the design of this study follows closely that of Roe (1953b) and Cattell and Drevdahl (1955; Drevdahl & Cattell, 1958) both in subject matter and in choice of eminent scientists as representatives of highly creative persons. It attempts to improve on these studies, however, by using larger samples of subjects, by using control groups matched on the variables of sex, age, education, discipline, and opportunity to do research, and by using measuring instruments which have had the variables they purport to measure anchored by validity studies to outside criteria.

Chapter II. Research Design

Definition of Terms

Creativity. As used in this study, creativity is a process through which products emerge which are new or novel to civilization. Creative persons, therefore, are considered to be individuals who have produced such products.

Productivity. As herein used, productivity refers to the number of scientific articles, books, or patents produced by a scientist. This was not used as one of the criteria for selection of subjects.

Eminence. In this study, eminence refers to the identification of persons by society on the basis of major research contributions. As will be noted later, creative scientists and eminent scientists are thus synonymous in this study.

Subjects and Criteria

In line with the above definition, subjects were chosen who had given evidence of having produced one or more products which were new or novel to civilization. Essentially, persons were chosen who had achieved eminence as research scientists. In this way only creative persons should have been identified as subjects, although probably some creative persons were omitted since it is probable that not all creative researchers achieve eminence for their work, especially if it is done in an obscure or "unpopular" scientific area.

Four groups of male scientists were selected, all under 65 years of age and currently residing in the United States or Canada. Men responsible for the tests used in the study were excluded. Two groups (chemists and psychologists) were chosen for their eminence as research scientists, and two control groups were chosen on the basis of their lack of eminence.

The eminent scientists were chosen from seven sources: (a) the membership roster of the National Academy of Sciences; (b) the membership list of the American Philosophical Society; (c) scientists starred in American Men of Science from 1903-43 as indicated by Visher (1947) in Scientists Starred 1903-1943; (d) the roster of selected general authorities from Who Knows--and What (1954); (e) Who's Who in America (1959); (f) the membership list of the Society of Experimental Psychologists (a society to which a limited number of psychologists is elected on the basis of distinguished work); and (g) the list of well-known psychologists identified by Clark (1957). Equal numbers of creative and control subjects were selected in the areas of psychology (as representative of the social sciences) and chemistry (as representative of the physical sciences). The control groups were chosen from the membership lists of the professional societies of the two disciplines, with selection restricted to individuals who were not listed in any of the sources from which the other groups were formed. Each control subject was chosen to match some eminent subject as closely as possible on the bases of age, amount of education, and opportunity to do research. These lists of creative

and noncreative scientists were submitted to a number of mature scientists within each discipline. These persons were asked to eliminate from the lists the names of those persons who, in their opinion, did not qualify to serve as a member of the group for which they had been chosen.

Creative and control groups each contained 200 individuals in the field of chemistry and approximately 170 each in psychology. The total sample thus consisted of about 740 scientists.

Measuring Instruments

Instruments used in the major study included an 81-item Biographical Inventory developed by the author (covering personal data; job-related behavior and attitudes; undergraduate, secondary, and primary school training; and home life in childhood and youth); Factors E, F, H, M, and Q_2 from Cattell and Stice's (1957) 16 Personality Factor (PF) Questionnaire; Items 51-75 from Maslow's (1952) Security-Insecurity Inventory; and the Initiative Scale from Ghiselli's (1954, 1955) Self-Description Inventory.

These measuring instruments were selected on the basis of four considerations: (a) the relevance of the factors they purport to measure to the factors selected for measurement on the basis of the results of previous research; (b) evidence as to the validity of the instrument; (c) the need for self-administered instruments (so as to be able to be used in a questionnaire-type study); and (d) their suitability for the population concerned.

Because of the need for self-administration, personality instruments of the projective type were eliminated. Many other instruments were excluded as unsuitable for the population concerned. The Minnesota Multiphasic Personality Inventory, for example, seemed to be oriented too much towards mental illness rather than towards the differentiation of mentally healthy individuals. The tests which were selected were all relatively new instruments in the measurement field, but in three cases they had been developed only after extensive research.

Biographical Inventory. This was developed on the basis of the works of Roe (1953a), Visher (1948), Knapp and Goodrich (1952), and Terman (1954).

The 16 P. F. Questionnaire. Developed and studied extensively in recent years through factor -analytic techniques, this test consists of items measuring 16 factors, of which 15 are personality-type dimensions and one represents a measure of general intelligence. The factors of importance to this study are those designated E (Dominance versus Submission), F (Enthusiasm and Cheerfulness versus Seriousness and Introspectiveness), H (Adventurousness versus Timidity) M (Creativity versus Conventional Outlook), and Q_2 (Self-Sufficiency versus Group Dependency).

Security-Insecurity Inventory. A test composed of items of clinical derivation, its purpose is to detect and measure feelings of security. The complete test (75 items) correlates highly with the Thurstone Neurotic Inventory and the Bernreuter Measure of Neurotic Tendency.

Initiative Scale. This is an unpublished instrument consisting of 64 pairs of descriptive adjectives (32 positive and 32 negative) paired on the basis of social acceptability. The respondent is forced to choose one from each pair in the first 32 as the more descriptive of himself, and one from each pair in the latter 32 that is less descriptive of himself (Ghiselli, 1954).

An initiative key was developed for this instrument by having several hundred students evaluate their motives with respect to jobs (whether they preferred steady employment, a chance to show initiative, fair supervision, etc.), selecting extreme groups on the basis of preference for initiative or lack of it, and then determining differences on the items between the groups.

Validation was sought by examining scores of men who were candidates for management positions rated on initiative as recorded in work history, scores of foremen rated for job success, of managers rated for job success, and for line workers rated for success in an occupation in which initiative should have been associated with failure. Correlations were in the predicted direction, being .57, .24 , .35, and -.29, respectively (Ghiselli, 1955).

What is initiative in the above sense? Ghiselli (1956) says a person high in this trait"is thought of as an inaugurator or originator who opens new fields, or conceives of new ways of doing things" (p. 312).

Procedure

Two pilot studies were conducted. The first was concerned primarily with the mechanics of the research, i.e., to determine the clarity of the directions, to see if items were both appropriate and clearly written, and to make sure items were not offensive. For this preliminary study staff members of the Lansing Board of Education and certain members of the Michigan State University Department of Psychology served as subjects. The materials were mailed to them with a request for criticism on the above counts.

On the basis of these comments the research materials were revised and two forms of the tests prepared. These were identical except for their length. The long form contained all of the instruments enumerated under the section on Measuring Instruments, plus Factors A, E, and Q_1 from the 16 P. F. Questionnaire, while the short form contained all of the above except items from Maslow's Security-Insecurity Inventory, 25 of the Biographical Inventory items, and Factors G and H from the 16 P. F. Questionnaire.

In the second pilot study, the long form was mailed to 15 creative chemists and 15 creative psychologists, as well as to 15 non-eminent men in each field. The short form was also mailed to equal numbers in each group (total N = 120). A personal letter was mailed several days ahead of the form to each individual. This letter explained the study, assured anonymity of response, requested co-operation, etc. Other procedures which were used to increase the

percentage of returns included: (a) the enclosure of a post card with the initial letter, to be used if the person wished a copy of the results; (b) a stamped envelope (addressed to the investigator) to be included with the printed questionnaire; and (c) a follow-up letter sent two weeks later (Goode & Hatt, 1952).

The second pilot study resulted in a 50% return. A statistical analysis of the results (tests of significance between creative and control groups) led to the elimination of Factors A, G, and Q_1 in the Cattell-Stice questionnaire and a number of items from the Biographical Inventory.

The procedure followed in the main study was identical to that in the second pilot study, except that only the printed form of the short test battery was used (see appendix for copy of questionnaire). Since returns were unsigned, some other method was needed in order to identify the group to which the returned questionnaires should be allocated. Color coding was therefore added.

Chapter III. Results

Characteristics of the Responding Sample

A total of 438 forms were returned in usable condition, representing a return of approximately 60%. These forms were then grouped according to discipline, i.e., psychologists and chemists; and within each discipline creative was compared with control.

Throughout the study the various groups will be identified by letters, as follows: EP, creative psychologists; CP, control psychologists; EC, creative chemists; CC, control chemists; P, psychologists; and C, chemists.

Since both creative and control begin with C, the alternate letter E will be used for the creative group, indicating achievement of "eminence."

The characteristics of the various groups and of the total sample in relation to number of doctorates, age, and type of employment are given in Table 1, followed by specialization within the discipline in Tables 2 and 3. It may be noted that almost all subjects hold the doctorate and that most are employed in an educational setting.

Methods of Analyses

Measures of central tendency and variability were computed for each group for the 16 P. F. scales, the Security-Insecurity

Table 1. Number of doctoral degrees, age, and employment of subjects

Variable	EP	CP	EC	CC	P	C	Total Group
Doctoral Degrees	109	102	104	116	211	220	431
Age[a]	49.5	50	56	54	50	55	53
Employment							
Educational	99	89	75	110	188	185	373
Industrial	4	2	20	6	6	26	32
Governmental	4	10	8	1	14	9	23
Other	3	1	3	0	4	3	7
Not listed	0	1	2	0	1	2	3
Total	110	103	108	117	213	225	438

[a] Figures in this row are medians.

Table 2. Areas of specialization of psychologists

Area	EP	CP	All Psychologists
General-Experimental	50	22	72
Clinical	12	30	42
Industrial	9	7	16
Social	8	6	14
Quantitative	11	5	16
Educational	1	19	20
Other	17	12	29
Not indicated	2	2	4
Total	110	103	213

Table 3. Areas of specialization of chemists

Area	EC	CC	All Chemists
Organic	12	22	34
Inorganic	2	8	10
Physical	27	20	47
Biochemistry	21	29	50
Other	17	16	33
Not indicated	29	22	51
Total	108	117	225

Inventory, and the Ghiselli Initiative Scale. Tests of significance were then computed between creative and control groups within each discipline, as well as between psychologists and chemists on all of the test scores and for each biographical item. Finally, average scores for each group and for the full sample on the 16 P. F., Security-Insecurity, and Ghiselli scale were converted so as to compare them with student and general population norms.

The .05 level of confidence was chosen as the cut-off point for interpretation of findings as significant. This level was chosen since the study is in an area still in the pioneer stages of exploration where findings must be substantiated by further research, and what is needed most is to discover significant landmarks. Therefore, even though 1 of each 20 significant findings could be expected not to be replicable, the use of the .01 or similar significance level was considered a less satisfactory solution due to the loss of possibly significant suggestive leads.

Compound Probability. Katzell (1951) and others have pointed out the need for an independent check on the validity of both items and tests; and indeed, Katzell indicates that if items are to be combined into a test, unless an independent check is made on the original item validities and this information combined with the original validity data, the greatest amount of shrinkage will occur in future validity checks on independent samples, since "the items of highest manifest validity are those most likely to have the largest chance deviations in the positive (or valid) direction from their true validities" (p. 18). To overcome this he suggests that samples be split

in half, validity measures obtained on both samples, and the resulting p values combined into a compound probability with selection of items then being based on these new p values. Katzell indicated that the compound p value was equal to the product of the two p values. Baker (1952), however, showed that compound probability is not equal to the product of the two p values, but rather to a more conservative value found by obtaining the probability of chi square with four degrees of freedom where $X^2 = -2 \log_e p1\ p2$. He presented a figure (Baker, 1952, p. 305) indicating the p values needed to reach compound significance at the .01, .05, and other levels. This figure indicated that two p values at the .10 level fell roughly at the .05 level of compound probability.

In the study at hand, it was felt that the statistical design should maximize the amount of information to be obtained from a given amount of computation and should provide, whenever feasible, for an independent check of the observations. Tests of significance were therefore computed between creative and control groups within each discipline, with differences noted that were significant both at the .10 level and at the .05 level. By interpreting differences found on both comparisons (in the same direction) at the .10 level as significantly differentiating creative from control scientists (thus adhering to the .05 level, although this approach is a slightly more conservative one than advocated by Baker), an independent check of the initial results was permitted, with interpretations based on compound probabilities. By examining those tests and items on which

differences were found on only one of the two comparisons, and interpreting only findings at the .05 level or beyond as significantly differentiating creative from control scientists within a given discipline, an examination of creativity among and within the sciences was permitted.

There was no necessity to subdivide the psychologists' group when comparing them to chemists (other than for compound probability purposes). The decision was therefore made to compare these total groups and to depend on future research for an independent check on the results.

The specific statistical measures used in connection with the personality tests and biographical items are given below.

The 16 P. F. Questionnaire and the Ghiselli Scale. Since Cattell and Stice (1957, Tabular Supplement, p. 22) have shown that several of the 16 P. F. factors change with age, it was felt necessary to test for significance between groups on the age variable. The results indicated no significant age differences between creative and control groups, and t tests were therefore computed in order to test the significance of the differences between these groups. Significant differences in age were found, however, between psychologists and chemists. In order to control the influence of age, analysis of covariance, with age as a control variable, was used to test for significant differences between the groups.

Security-Insecurity Inventory. Maslow (1952, p. 7) reported that scores on the Security-Insecurity Inventory do not distribute

normally, but instead are skewed toward the secure end of the continuum. He recommended that this be taken into account in all statistical manipulations of these data. Therefore, medians and semi-interquartile ranges were computed as measures of central tendency and variability, while median tests were used to test for differences between the groups. Although desirable to equate statistically the chemists' and psychologists' groups on the basis of age, a check of Edwards (1950, 1954), Guilford (1956), Siegel (1956), and other sources indicated no way of controlling a relevant variable when dealing with data requiring nonparametric treatment.

Biographical Inventory. All biographical items were tested for significance through the use of the chi square. All response options were included in the analyses. Again, as in the case of the Security-Insecurity Inventory when comparing psychologists to chemists, age was permitted to vary since no method was available by which it might be statistically controlled when dealing with frequency data. Since many of these items dealt with factual events which had occurred in the earlier lives of the scientists, however, the effect of this uncontrolled variable would seem to be of less significance than the possible effect of age on personality factors.

Creative Compared with Control Scientists

Measures of central tendency, variability, and tests of significance on personality tests are given in Table 4. Tests of significance on biographical items appear in Table 6.

Table 4. Comparison of creative and control psychologists and chemists on personality tests

Factor	Psychologists					Chemists				
	Creative		Control			Creative		Control		
	CT[a]	V[b]	CT[a]	V[b]	t test	CT[a]	V[b]	CT[a]	V[b]	t test
E	14.98	3.27	13.92	3.48	2.34*	14.15	3.52	12.91	3.89	2.53*
F	9.34	3.41	9.13	3.21	.47	9.14	3.17	8.66	3.44	1.11
M	12.84	3.43	12.25	3.40	1.27	11.80	3.05	11.61	3.02	.48
Q_2	13.63	2.60	11.92	3.35	4.14*	13.42	3.00	12.96	2.37	1.29
H	13.69	4.59	14.11	4.23	.70	13.65	3.79	12.99	4.21	1.26
S-I	6.50	4.03	6.00	3.05	1.35	6.00	2.97	7.00	3.06	1.00
Gh	34.44	6.68	28.06	7.68	6.63*	33.18	8.14	29.38	7.79	3.66*

Note.--Abbreviations are as follows: from Cattell's 16 P. F. Questionnaire E--Dominance, F--Enthusiasm, M--Creativity, Q_2--Self-Sufficiency, and H--Adventurousness; S-I, Security-Insecurity Inventory; Gh, a measure of initiative from Ghiselli's Self-Description Inventory. Median scores were computed for S-I; all other average scores represent means. Semi-interquartile ranges were computed for S-I; all other such measures are standard deviations. Median test used for S-I. N varies from 213 to 225.

[a] Measure of central tendency. [b] Variability. *$p < .05$

Personality Tests. Two major findings in this analysis are: (a) creative scientists are more dominant than control scientists (higher mean E score); and (b) they have more initiative (higher mean score on the Ghiselli scale). Items comprising these significant inventories appear in Table 5.

Biographical Items. Significant differences were found on 16 items, as reported in Table 6. Specifically, the creative scientists more often had fathers who were professional men. They graduated from high school at a younger age than control scientists, and later, more often achieved a straight A average in their major and in their over-all grade-point average both as undergraduates and as graduate students. They spent many more hours per week (in excess of 50) on study and research while in graduate school, published more articles then, and more often had their graduate school expenses met through scholarships and fellowships as opposed to part-time work.

As mature scientists, the creative men still show this strong motivation. They read more professional journals and present more papers at conventions. They produce, of course, many more articles than the control scientists.

Several factors unrelated to ability and motivation also discriminated the two groups. The highly creative men in their current lives show significantly more often either no preference for, or little or no interest in, religion and also make few or no commitments to civic and community affairs. A final finding, of possible interest

Table 5. Items constituting significant personality tests, creative compared with control scientists

Inventory	Item no.	Item content
Factor Inventory		
Factor E	2	I make smart, sarcastic remarks to people if I think they deserve it. a. Generally b. Sometimes c. Never
	13	I have some characteristics in which I feel superior to most people. a. Yes b. Uncertain c. No
	33	I occasionally tell strangers about the things I am interested in and good at, without direct questions from them. a. Yes b. In-between c. No
	39	If the odds are really against something's being a success, I still believe in taking the risk. a. Yes b. In-between c. No
	40	I like it when I know so well what the group has to do that I naturally become the one in command. a Yes b. In-between c. No
	46	I have sometimes been described as a rather headstrong person, following my own ideas regardless of the opinions of others. a. Yes b. In-between c. No

Table 5--continued

Inventory	Item no.	Item content
Factor Inventory		
Factor E	47	I believe I am better at showing: a. Courage in meeting challenges b. Uncertain c. Tolerance of other's views
Self-Description Inventory		
Initiative Scale	3	a. Cooperative b. Inventive
	9	a. Industrious b. Practical
	11	a. Unaffected b. Alert
	12	a. Sharp-witted b. Deliberate
	17	a. Affectionate b. Frank
	19	a. Sincere b. Calm
	21	a. Poised b. Ingenious
	25	a. Responsible b. Reliable
	32	a. Honest b. Generous
	33	a. Shy b. Lazy
	35	a. Noisy b. Arrogant
	47	a. Changeable b. Prudish
	53	a. Weak b. Selfish
	57	a. Opinionated b. Pessimistic
	59	a. Hard-hearted b. Self-pitying
	60	a. Cynical b. Aggressive
	61	a. Dissatisfied b. Outspoken

Table 6. Comparison of creative and control psychologists and chemists on significant Biographical Inventory items

Item No.	Psychologists X^2	Chemists X^2	Item content
3	17.36**	7.95*	My religious preference is: a. Protestant b. Catholic c. Jewish d. Other e. No preference
4	8.57*	23.15**	I would classify my interest in religion as: a. Strong b. Moderate c. Little d. None e. Opposed to religion
8	25.80**	10.52**	I would classify my commitments in civic and community activities as: a. Quite heavy b. Moderate c. Light d. None
10	15.01**	19.94**	My graduate grade-point average was: a. A b. A minus c. B plus d. B e. B minus or less
11	15.10**	10.46**	While in graduate school I devoted the following approximate amounts of time each week during the school year to my studies or to related research (include time spent in classes): a. 30 hours or less b 31 to 40 hours c. 40 to 50 hours d. 50 to 65 hours e. 65 hours or over

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
12	22.53**	12.61**	While in graduate school, I had the following number of scientific articles published: a. None b. One c. Two d. Three e. Four or more
13	23.96**	15.85**	My expenses in graduate school were met largely through: a. Scholarships or fellowships b. Assistantships c. Own savings or part-time work d. Parents e. Other
21	19.98**	14.33**	My over-all undergraduate grade-point average was: a. A b. A minus c. B plus d. B e. B minus or less
22	18.99**	16.78**	My undergraduate grade-point average in my major subject was: a. A b. A minus c. B plus d. B e. B minus or less
23		10.74**	During college I was a member of: a. More than two honor societies b. Two honor societies c. One honor society d. No honor societies
26		24.14**	When I received my undergraduate degree I was: a. Over 22 b. 22 c. 21 d. 20 e. Under 21

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
29		6.00**	In high school I; a. Was not a member of any athletic teams b. Was active in one or two sports. c. Was quite active in sports
34		9.16**	My work in high school mathematics was considered: a. Outstanding b. Good c. Fair d. Poor
35	7.80*	16.81**	When I graduated from high school I was: a. 19 or older b. 18 c. 17 d. 16 e. Under 16
37		9.95**	My position in the family was: a. Oldest child b. Oldest son, but not oldest child c. About the middle d. Youngest child e. Only child
41	13.06**	9.59**	My father's occupation: a. Professional b. Business Executive c. Farmer d. Factory or office worker e. Other
47	7.88**		I would describe the family in which I was raised as: a. Closely knit b. Lacking in warmth c. Individualistic, i.e., each person went his own way

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
59		6.17**	I felt that my family: a. Was different from others b. Was somewhat superior to others c. Neither of the above
61	19.39**	7.84**	Concerning research as a career or major interest: a. I "drifted" into it b. I chose it
62	19.08**		I first chose or accepted research as a career or major interest: a. After leaving graduate school.b. When I was in graduate school c. When I was an undergraduate d. When I was in high school e. Prior to entering high school
64	7.84*	18.81**	On the average, I keep up with the articles in: a. No scientific journals b. One or two scientific journals c. Three or four scientific journals d. Five or six scientific journals e. More than six scientific journals

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
65		35.16**	I am a member of the following number of professional organizations: a. None b. One or two c. Three or four d. Five or six e. More than six
66		27.30**	I attend the following approximate number of professional conventions each year: a. None b. One or two c. Three or four d. Five or six e. More than six
67	33.01**	21.30**	I deliver a paper at a professional convention: a. Rarely or never b. Every year or so c. At least once a year d. Two or three times a year e. Four or more times a year
68	6.04**		My opinion concerning most professional conventions is that: a. They are professionally stimulating and therefore of value b. They are sometimes interesting and sometimes a waste of time c. They are of primary value to the socially oriented individual and of lesser value to research oriented individuals

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
69		12.51**	I spend the following approximate number of hours weekly in connection with my work (including time spent both at my place of employment and elsewhere): a. 30 or less b. 31 to 40 c. 40 to 50 d. 50 to 65 e. 65 or over
71	11.25**		In relation to my work, I: a. Am completely happy only when working b. Get a great deal of satisfaction from it c. Get some satisfaction from it d. Am not too happy with my vocational choice e. Wish I had gone into another field
74		10.35**	Ideally, I think that the following number of hours per week should be spent in active research at the place of employment <u>if creative output is to be at a maximum</u>: a. Less than 20 b. 20 to 30 c. 30 to 35 d. 35 to 40 e. More than 40

Table 6--continued

Item No.	Psychologists X^2	Chemists X^2	Item content
76	29.98**	28.29**	Concerning professional positions, the most important one of the following factors, in my opinion, is: a. Opportunity for permanent work and advancement b. Stimulating associates and atmosphere conducive to research c. Opportunity to combine research work with teaching or administrative duties d. Opportunity to do really creative research and to choose problems of interest to me
80	61.17**	7.28**	I have the following number of scientific products to my credit:____number of published scientific articles (include joint publications)

Note--All item responses were tested for significance using the chi square except for Item 80, on which the median test was used

See text for interpretation of above findings

* $p < .10$

** $p < .05$

to employers of research personnel, was that when seeking a position the less creative scientists are predominantly concerned with opportunities to combine teaching and administrative duties with research, while the overwhelming choice for the creative scientists is the opportunity to do really creative research and to choose problems of interest to them.

The creative research man thus emerges as the dominant, strongly motivated individualist who is self-propelled and whose interests are channeled away from social and civic activities and are directed towards his own individual research problems.

Creative Compared with Control Scientists within Disciplines

The findings so far have been common to both psychologists and chemists. However, creative psychologists differ from control psychologists in other ways not found for chemists. Creative psychologists prove to be more self-sufficient than their controls (Factor $\bar{Q}_2$). Items comprising this factor appear in Table 7.

There are also significant differences on four more biographical items, indicating that: (a) creative men in this profession more often came from individualistic families in which each person went his own way; (b) the creative man chose research as a career at a younger age than his less creative contemporaries; (c) creative psychologists place less value on professional conventions than their controls despite the fact that they present more papers; and (d) creative psychologists derive much more satisfaction

Table 7. Items constituting significant personality test, creative compared with control psychologists

Inventory	Item no.	Item content
Factor Inventory		
Factor Q_2	12	When I was about fourteen and fifteen, I joined in school sports: a. Occasionally b. Fairly often c. A great deal
	17	I prefer to marry someone who can: a. Keep the family interested in its own activities b. In-between c. Make the family part of the social life of the neighborhood
	18	One can hardly do a thing these days without being regulated or exploited by "big business" or government agencies. a. Yes b. In-between c. No
	38	I like to do my planning alone, without interruptions and suggestions from others. a. Yes b. In-between c. No
	45	I learn better by: a. Reading a well-written book b. In-between c. Joining a group discussion

from their work than their less creative peers.

Creative Chemists. Creative chemists differ from their controls on an additional ten biographical items (there are no further differences in tests). These items indicate that as far back as childhood there were differences in achievements, feelings, etc., of the creative chemists as contrasted to the less creative ones. The creative chemists were usually the middle or older children. At relatively early ages these children considered their families to be superior to others. In high school these creative children exhibited their strong intellectual orientations by shunning sports and excelling in mathematics. This strongly expressed intellectual ability and motivation continued through undergraduate school as evidenced by membership in many honor societies and graduation at an early age. As adults these creative chemists are still exhibiting this exceptionally strong intellectual drive, now channeled into professional activities as evidenced by their membership in many professional organizations and attendance at many professional conventions each year, as well as spending long hours each week at their work. Further, many more of these men than their controls believe that 40 hours or more per week should be spent in active research if creative output is to be maximized.

Additional Statistical Check. In order to determine whether significant differences between creative and control groups could be due to artifacts of greater weighting with certain subspecialties,

such as experimental psychologists, the significant factors (E and Gh for both, Q_2 for psychologists only) were examined by comparing scores of the subspecialties within each creative and control group through the use of analysis of variance. It was reasoned that, in order for these subspecialties to have influenced the results, it would first be necessary to show a difference in their mean scores within a given group. In all cases except one, no significant differences were found. In the one case indicating a significant difference, the direction of the difference indicated that differential weighting in subspecialties did not account for significant differences between creative and control groups on factor tests. Since these results were all of the same nature, no further analyses of this type were felt necessary in regard to the biographical items.

Psychologists Compared with Chemists

Although the major findings of the study have been presented in the preceding section, it was felt that an examination of the data relevant to the differences between scientists within disciplines and between scientists and other groups would be helpful since such information is necessary to the field of vocational guidance and strongly ties in with the early identification and encouragement of students having creative potential in the science area.

Personality Tests. Measures of central tendency and variability for both psychologists and chemists on the tests, as well as tests of significance, are presented in Table 8. As indicated earlier, analysis of covariance was used rather than t tests, since significant differences in age had been found between these two groups. Analysis of covariance permitted the age variable to be statistically controlled. As may be noted, one significant difference was found, indicating psychologists to be more bohemian, introverted, unconventional, imaginative, and creative in their thinking and behavior than chemists (Factor M). Items comprising this inventory appear in Table 9.

Biographical Items. Table 10 indicates that significant differences were found on 36 items. These differences emerged as early as childhood years.

As children, more psychologists were reared in the northeast than the chemists, the latter more often being reared in the midwest or in a foreign country. As children, the psychologists felt there was less affection and understanding between themselves and their fathers than did the chemists, and further, that their parents were not as accepting of them. The psychologists tended to reject positive childhood images of their parents, instead recalling the rebelliousness they felt in regard to parental authority. In reference to values in the homes, too, psychologists' parents differed by more often placing little value on education and learning or by

Table 8. Comparison of psychologists and chemists on personality tests

	Psychologists		Chemists		
Factor	CT[a]	V[b]	CT[a]	V[b]	Analysis of covariance
E	14.47	3.41	13.51	3.78	2.00
F	9.23	3.31	8.89	3.32	.04
M	12.55	3.42	11.70	3.03	4.76*
Q_2	12.80	3.10	13.18	2.69	2.27
H	13.89	4.41	13.31	3.96	1.75
S-I	6.00	3.00	6.00	3.00	.33
Gh	31,37	7.84	31.24	8.17	.04

Note.--Median scores were computed for S-I; all other average scores represent means.

Semi-interquartile ranges were computed for S-I; all other such measures are standard deviations.

Median test used for S-I.

N varies from 212 to 220.

[a] Measure of central tendency.

[b] Variability.

* $p < .05$.

Table 9. Items constituting significant personality test, psychologists compared with chemists

Inventory	Item no.	Item content
Factor Inventory		
Factor M	10	I like a friend (of my sex) who: a. Seriously thinks out his attitudes to life b. In-between c. Is efficient and practical in his interests
	11	My deeper moods sometimes make me seem unreasonable, even to myself. a Yes b. In-between c. No
	16	My memory tends to drop a lot of unimportant, trivial things, for example, names of streets or shops in town. a. Yes b. In-between c. No
	23	One should be careful about mixing with all kinds of strangers, for there are dangers of infection and other things. a. Yes b. Uncertain c. No
	29	My artistic feelings sometimes outweigh common sense. For example, I would not live in a wrongly decorated apartment even if it saved money. a True b. Uncertain c. False

Table 9--continued

Inventory	Item no.	Item content
Factor Inventory		
Factor M	30	I like to: a. Be free of personal entanglements b. In-between c. Have a circle of warm friendships, even if they are demanding
	36	The teaching of different beliefs about right and wrong is: a. Always interesting b. Something we cannot avoid c. Unpleasant and wasteful

Table 10. Comparison of psychologists and chemists on significant Biographical Inventory items

Item no.	X^2	Item content
3	23.66*	My religious preference is: a. Protestant b. Catholic c. Jewish d. Other e. No preference
4	39.52*	I would classify my interest in religion as: a. Strong b. Moderate c. Little d. None e. Opposed to religion
6	17.59*	When I get any free time: a. I enjoy watching or participating in sports most of all b. I enjoy outdoor activities (other than sports) most of all c. I enjoy indoor, individual activities most of all d. I enjoy social activities most of all
9	37.52*	My present feelings towards my parents (or feelings prior to their deaths, if deceased) could well be expressed as: a. Considerable love and affection b. High regard c. Sincere admiration for father, affection for mother d. Relatively indifferent e. Wish I could accept their behavior toward me with good grace but find it difficult
11	17.51*	While in graduate school I devoted the following approximate amounts of time each week during the school year to my studies or to related research (include time spent in classes): a. 30 hours or less b. 31 to 40 hours c. 40 to 50 hours d. 50 to 65 hours e. 65 hours or over

Table 10--continued

Item no.	X^2	Item content
13	23.99*	My expenses in graduate school were met largely through: a. Scholarships or fellowships b. Assistantships c. Own savings or part-time work d. Parents e. Other
15	23.25*	Attendance costs at the school, in relation to other undergraduate schools, were: a. Quite high b. Fairly high c. Average d. Below average
18	18.21*	The department in which I took my undergraduate major: a. Had a departmental club, of which I was a member b. Had a departmental club, but I did not join it c. Had no departmental club
19	85.68*	In my opinion, my undergraduate department, as compared to other departments in the school, had: a. Severe requirements b. Fairly stiff requirements c. Moderate requirements d. Light requirements e. Very easy requirements
21	25.67*	My over-all undergraduate grade point average was: a. A b. A minus c. B plus d. B e. B minus or less
26	12.86*	When I received my undergraduate degree I was: a. Over 22 b. 22 c. 21 d. 20 e. Under 21
27	11.94*	During my high school years I spent the majority of my free time: a. Dating or running around with "the gang" b. Reading or studying c. Participating in various sports d. In connection with my hobbies e. Other

Table 10--continued

Item no.	X^2	Item content
28	23.51*	In high school I participated in: a. No clubs b. One club c. Two or three clubs d. Four or more clubs
29	6.36*	In high school I: a. Was not a member of any athletic teams b. Was active in one or two sports c. Was quite active in sports
30	33.38*	I began dating when I was: a. 23 or over b. 20 to 22 c. 17 to 19 d. 14 to 16 e. 13 or under
33	72.60*	In high school my favorite subject was: a. Mathematics, chemistry, or physics b. English, foreign languages, or social studies c. Technical subjects d. Other
34	26.16*	My work in high school mathematics was considered: a. Outstanding b. Good c. Fair d. Poor
44	17.39*	When I was a child, the house I lived in was located in the: a. Northeast b. Midwest c. South d. Far west e. Foreign country
49	9.76*	As a child, my parents: a. Dominated and/or overprotected me b. Encouraged me to do things on my own c. Were primarily concerned with their own affairs d. Did not accept me or give me as much attention as I felt I needed e. None of the above

Table 10--continued

Item no.	X^2	Item content
50	12.46*	As a child, I felt that my parents: a. Loved me a great deal b. Were kind and considerate of me c. Were warm and affectionate towards me d. Were fine individuals, and that my father was a successful person e. None of the above
51	12.08*	When I was a child, I: a. Rebelled against my parents b. Accepted the discipline of my parents, but was inwardly rebellious against it c. Accepted the discipline of my parents without being too concerned about it d. Wished that my parents would be more strict with me e. None of the above
52	16.30*	In my childhood there was: a. More than moderate affection and understanding between my father and me b. Average affection and understanding between my father and me c. Less than moderate affection and understanding between my father and me d. Practically no affection and understanding between my father and me
56	10.38*	In the home in which I was reared, education and learning: a. Were not especially valued b. Were valued for their own sake c. Were valued as investments for future security d. Were valued in the light of the aid they provide in achieving financial success and/or social prestige e. None of the above

Table 10--continued

Item no.	X^2	Item content
60	102.86*	I chose my profession: a. When I was in graduate school b. During my junior or senior year in undergraduate school c. During my freshman or sophomore year in undergraduate school d. When I was in high school e. Prior to entering high school
61	31.33*	Concerning research as a career or major interest: a. I "drifted" into it b. I chose it
62	27.40*	I first chose or accepted research as a career or major interest: a. After leaving graduate school b. When I was in graduate school c. When I was an undergraduate d. When I was in high school e. Prior to entering high school
64	9.63*	On the average, I keep up with the articles in: a. No scientific journals b. One or two scientific journals c. Three or four scientific journals d. Five or six scientific journals e. More than six scientific journals
65	11.76*	I am a member of the following number of professional organizations: a. None b. One or two c. Three or four d. Five or six e. More than six

Table 10--continued

Item no.	X^2	Item content
68	19.51*	My opinion concerning most professional conventions is that: a. They are professionally stimulating and therefore of value b. They are sometimes interesting and sometimes a waste of time c. They are of primary value to the socially oriented individual and of lesser value to research oriented individuals
70	8.13*	I believe that I do my best research when: a. I work alone b. I work as a member of a group
71	13.95*	In relation to my work, I: a. Am completely happy only when working b. Get a great deal of satisfaction from it c. Get some satisfaction from it d. Am not too happy with my vocational choice e. Wish I had gone into another field
72	20.88*	Administrative aspects of scientific work: a. Interest me a great deal b. Are moderately interesting to me c. Are of little interest to me d. Are of no interest to me
73	17.21*	In research work, I believe that working hours should be: a. Standard, i.e., a regular eight hour day b. Flexible, so as to permit workers some freedom in choosing working hours c. Set by the individual alone

Table 10--continued

Item no.	X^2	Item content
74	69.34*	Ideally, I think that the following number of hours per week should be spent in active research at the place of employment <u>if creative output is to be at a maximum</u>: a. Less than 20 b. 20 to 30 c. 30 to 35 d. 35 to 40 e. More than 40
75	14.54*	In research work, work deadlines: a. Should be set by a superior b. Should be set by the individual or group concerned c. Should not be set at all
80	8.83*	I have the following number of scientific products to my credit:_____number of published scientific articles (include joint publications)

Note--All item responses were tested for significance using the chi square except for Item 80, on which the median test was used.

See text for interpretation of above findings.

* $p < .05$.

stressing their value in relation to achieving financial success and social prestige rather than as having value in their own right.

As adolescents, the psychologists continued their emotional pattern by expressing more often than chemists the feeling of being isolated or apart from others. Perhaps to compensate for this, psychologists during this period began dating at a younger age than the chemists and continued dating more actively than chemists during their high school years. They also were more active in clubs and in high school sports. Their favorite subjects were English, foreign languages, or social studies, while the chemists preferred mathematics, physics, or chemistry. The latter group also performed much better in mathematics than did the psychologists.

As undergraduates the psychologists more often than the chemists paid their own way through schools and attended ones with below-average costs. This financial problem may have retarded their progress somewhat, since chemists tended to be younger than psychologists upon receiving their undergraduate degrees. The undergraduate departments of psychology were more often characterized by respondents as maintaining moderate academic requirements and having no departmental club, while the chemistry departments were characterized by maintaining fairly stiff to severe academic requirements and by having a departmental club of which most respondents were members. The undergraduate grade-point averages of the psychologists also were considerably below that of the chemists.

In graduate school the psychologists continued to show the lesser intellectual motivation evidenced in comparisons with chemists at earlier ages, in that during graduate school they spent less time than the chemists each week in relation to studies and research. The chemists also seemed to "mature vocationally" faster than the psychologists, in that they made an earlier choice of career. Psychologists more often than the chemists "drifted" into research as a career.

As adults, the psychologists still manifest some of the individualistic, aloof behavior evidenced in their child hood years, maintaining feelings of indifference or passive hostility toward their parents, while the chemists have a high regard for theirs (this finding held up even when comparing experimental psychologists alone with chemists). Psychologists more often show no preference for or little interest in religion than the chemists, who profess a fair amount of interest, predominantly in Protestant faiths. The general social orientation of the psychologists continues to show itself in their greater preference for social activities during their free time.

In relation to the attitudes and behaviors of the two adult groups concerning their professions, chemists read and publish more scientific articles, but join fewer professional organizations. They also have a higher opinion of professional conventions; are more interested in group research and in administrative aspects of research

than are psychologists; and they more often believe 40 hours or more per week should be spent in active research if creative output is to be maximized, while psychologists argue for 20 or 30 research hours per week. Also, chemists believe work hours should be flexible and work deadlines set by the group, while psychologists favor individual freedom in relation to both work hours and deadlines. Finally, the chemists are apparently more immersed in their work and gain greater pleasure from it than do the psychologists.

All of the findings pertaining to comparisons of psychologists and chemists relative to biographical items must be viewed with caution, of course, for as indicated earlier, median ages for the groups varied significantly and could not be controlled statistically.

Scientists Compared with College Students and with the General Population

As compared with students (see Table 11) and considering only scores of 4 or less, or 7 or more, as indicating a definite deviation from the average (Cattell & Stice, 1957, p. 7), the scientists as a group appear to be more silent and introspective (Factor F) and aloof and withdrawn (Factor H) than the "average" male college student as well as more self-sufficient and resourceful (Factor Q_2). Further, this pattern seems characteristic of all the groups comprising the total sample.

Table 11. Mean scores on Cattell factors based on (male) college student norms[a]

Factor	EP	CP	EC	CC	P	C	All subjects	Normative M[b]
E	6	5	5	5	5	5	5	(5.5)
F	4	4	5	4	4	4	4	(5.5)
M	7	6	6	6	7	6	6	(5.5)
Q_2	8	7	8	8	8	8	8	(5.5)
H	3	3	3	3	3	3	3	(5.5)

Note.--Average scores on Factors F and H were corrected for age.

[a] Based on N of 364 men averaging 21 years of age (Cattell & Stice, 1957)

[b] Scores are expressed as stens, which are scales in which 10 equal points cover the population with mean of 5.5.

In relation to the general adult male population (see Tables 12 and 13), scientists differ in much the same ways as from the students, except that they appear somewhat less withdrawn than the student comparison showed them to be (Factor H), but also more unconventional, imaginative, and creative when compared to the average man (Factor M).

Table 12. Mean scores on Cattell factors based on (male) population norms [a]

Factor	EP	CP	EC	CC	P	C	All subjects	Normative M[b]
E	5	5	5	4	5	5	5	(5.5)
F	2	2	2	2	2	2	2	(5.5)
M	8	8	8	8	8	8	8	(5.5)
Q_2	8	7	8	8	8	8	8	(5.5)
H	5	5	5	5	5	5	5	(5.5)

[a] Cattell and Stice (1957).

[b] Scores are expressed as stens, which are scales in which 10 equal points cover the population range with mean of 5.5.

Table 13. Average scores on Ghiselli Initiative Scale[a] and Security-Insecurity Inventory[b] in relation to adult population

Test	EP	CP	EC	CC	P	C	All subjects	Normative M
Ghiselli (%)	74	38	69	43	56	56	56	(50)
S-I (rating)	Average, all groups							

Note.--Mean scores computed for the Ghiselli scale, median scores for S-I.

[a] Norms based on N of 150 males.

[b] Norms based on N of 2020 males and females, predominantly college students and prison inmates.

Chapter IV. Discussion

Creative Compared with Control Scientists

Personality Factors. Results of the various investigations are presented in Table 14. As may be noted, Roe's (1953a) and Barron's (1959) findings have been supported to a greater extent than those of Cattell (1959) and Cattell and Drevdahl (1955).

Thus the creative scientist emerges as a strongly motivated, dominant person who is not overly concerned with other persons' views or with obtaining approval for the work he is doing (biographical factors and Factors E and Q_2). He is not the type of person who waits for someone else to tell him what to do, but rather thinks things through and then takes action on his own with little regard to convention or current "fashion" (Initiative Scale and Factor Q_2). He then is prepared to face the consequences of making unpopular decisions or of pursuing unconventional paths in his search for evidence relating to nature's laws (Factors E and Q_2).

Two other factors which have been hypothesized by various investigators as relating to creativity, i.e., persistence and energy level, apparently tie in with the above factors and appear promising as predictors when satisfactory instruments measuring these traits become available.

Returning again to the Cattell studies, the apparent reason

Table 14. Personality characteristics of creative scientists

Characteristic	Investigator(s) and measuring instruments	Present study and measuring instruments
Strong motivation	Roe (1953a)--over-all assessment Barron (1959)--over-all assessment	Supported--biographical factors
High degree of initiative	Roe (1953a)--over-all assessment Barron (1959)--over-all assessment	Supported--Ghiselli Initiative Scale
High self-sufficiency and independence	Roe (1953a)--over-all assessment Barron (1959)--over-all assessment Cattell & Drevdahl (1955)--Factor Q_2, 16 P. F. Questionnaire	Supported[a]--Factor Q_2, 16 P. F. Questionnaire
High degree of dominance	Cattell (1959)--biographical data Cattell & Drevdahl (1955)--Factor E, 16 P. F. Questionnaire	Supported--Factor E, 16 P. F. Questionnaire
Many basic insecurities	Roe (1953a)--over-all assessment	Not supported--items from Maslow's Security-Insecurity Inventory

Table 14--continued

Characteristic	Investigator(s) and measuring instruments	Present study and measuring instruments
High on adventurousness	Cattell (1959)--biographical data; Cattell & Drevdahl (1955)--Factor H, 16 P. F. Questionnaire	Not supported--Factor H, 16 P. F. Questionnaire
High introspectiveness	Cattell (1959)--biographical data Cattell & Drevdahl (1955)--Factor F, 16 P. F. Questionnaire	Not supported--Factor F, 16 P. F. Questionnaire

for the discrepancies between the present study and the Cattell studies lies in the lack of appropriate control groups in the latter investigations. That Cattell's factors do distinguish creative research men from some segments of the population is borne out by reference to Tables 11 and 12 (comparisons with student and adult general population norms), but apparently factors such as introversion-extraversion bear little relationship to achievement of creative research productivity, or so the results of this study imply.

The study also throws some light on another area of concern to many investigators, i.e., the relationship of mental health to creativity. Several investigators have been outspoken in their insistence on a relationship between these two concepts. Rogers (1959) and Maslow (1959), for example, have stressed "openness to experience" or "self-actualization" as basic for creativity, with both of these terms apparently referring to positive mental health. On the other hand, Roe (1953a) pointed out that many of the highly creative scientists she studied were experiencing rather severe emotional problems, and she therefore hypothesized basic insecurities as possible sources of the strong motivation to succeed in the lives of these persons. Mead (1959) also indicated a correlation of schizophrenic-like behavior with highly creative artistic productivity and well-adjusted, "happy" behavior with low-level creative artistic productivity in her South Pacific cultural studies. Historical studies of some highly creative artists, etc.,

also reveal a high incidence of neurotic or psychotic-like behavior among these persons.

The Maslow Security-Insecurity Inventory was included in this study in order to investigate the above, and, as noted in the preceding section, all groups were classified in the average range on Maslow's norms. Maslow (1952) stated, regarding his test, "the purpose of the S-I Inventory is to detect and measure the feeling of security (which as defined here is one of the most important determinants of mental health almost to the point of being synonymous with it)" (pp. 2-3), and again "security as defined here is almost synonymous with mental health" (p. 7). If this is accepted, then the results certainly offer no support for Roe's hypothesis or for the implications of Mead's studies in relation to creativity in science. But these findings give little support to the hypothesis that creativity is associated with the highest level of mental health, since average group scores were not in the "very secure" range, but rather were only average.

Biographical Items. Since there are so many findings to cover under this heading, only a brief comparison of the results will be given here.

First, in relation to childhood and family data, there were very few factors found to differentiate significantly the creative from the control scientists. Specifically, the socioeconomic class, being the first-born child, and similar factors previously found by Roe (1953a) and Visher (1948) to be characteristic factors in the

backgrounds of creative scientists were not found in this study to be associated to a significant degree with achievement of "creative" status as research scientists. One factor identified by both Roe and Visher, however, relating to the high incidence of fathers of creative scientists being professional men, was supported by this study.

A large number of factors differentiated the creative scientists from their controls concerning their activities from high school through adult life. On the whole, these supported Roe's (1953a) findings of early intellectual maturation (choosing their professions at an early age), strong motivation (as exemplified through studying long hours and making good grades as students, working long hours as adults, and producing many creative products), and strong work-oriented interests as adults, to the exclusion of religious, social, and community interests. No support was found for relating characteristics of undergraduate schools or departments to production of creative scientists (Knapp & Goodrich, 1952).

Special examination should be made, perhaps, of the religious factor, since this has been given so much attention by many investigators in relation to creativity in science. The finding most often made has been the preference for the Protestant religion on the part of the creative scientists, with very few eminent scientists showing a preference for Catholicism. This was noted by Roe (1953a), Knapp and Goodrich (1952)--in relation to production of scientists by Catholic institutions of higher learning--and others.

This study supports Knapp and Goodrich's findings in that only 1½% of all scientists included in this study attended undergraduate schools with Catholic affiliation. Further only 6% of all subjects came from homes in which the Catholic faith was preferred, while 77% came from Protestant homes. However, no relationship was found between achievement of creative status and religious preference. It appears, then, that religious preference is much more strongly associated with choice of science as a career than it is with achievement of highly creative productivity within a scientific discipline.

One final comment in relation to religion--Roe's findings relating to creative scientists' lack of interest in religion was supported. Even though their interest is small, however, it is interesting to note that most of them still classify themselves according to a particular religious preference.

Psychologists Compared with Chemists

Personality Factors. Table 15 summarizes the personality and biographical factors found by other investigators to be more characteristic of psychologists than of chemists. As may be noted, the majority of differences in personality characteristics found by Cattell and Drevdahl (1955) were not supported in this current study when the age variable was controlled. Since Cattell and Drevdahl did not control for age, the differences in results may be attributable to this statistical difference in the treatment of the data,

Table 15. Comparison of psychologists and chemists: findings on personality and biographical characteristics

Characteristic	Investigator(s) and measuring instruments	Present study and measuring instruments
Personality		
Psychologists more dominant	Cattell and Drevdahl (1955)--Factor E, 16 P. F. Questionnaire	Not supported--Factor E, 16 P. F. Questionnaire
Psychologists more enthusiastic and cheerful	Cattell and Drevdahl (1955)--Factor F, 16 P. F. Questionnaire	Not supported--Factor F, 16 P. F. Questionnaire
Psychologists more adventurous	Cattell and Drevdahl (1955)--Factor H, 16 P. F. Questionnaire	Not supported--Factor H, 16 P. F. Questionnaire
Psychologists more bohemian introverted, unconventional, imaginative and creative in thinking and behavior	Cattell and Drevdahl (1955)--Factor M, 16 P. F. Questionnaire	Supported--Factor M, 16 P. F. Questionnaire

Table 15--continued

Characteristic	Investigator(s) and measuring instruments	Present study and measuring instruments
Biographical		
Psychologists more rebellious against parents	Roe (1953a)--biographical data	Supported--biographical data
Psychologists more often have feelings of family superiority	Roe (1953a)--biographical data	Not supported--biographical data
Psychologists more socially oriented	Roe (1953a)--biographical data	Supported--biographical data

especially since his groups tended to differ in age in the same direction as the groups in the current study. (The mean ages for Cattell's research groups were: psychologists, 42.9; biologists, 48.7; and physicists, 51.4). Also to be considered, of course, is the fact that Cattell and Drevdahl studied only creative scientists, while the comparisons between psychologists and chemists in this study included both creative and control subjects.

Biographical Items. Table 15 also summarizes Roe's (1953a) results characterizing social scientists as opposed to physical scientists. On the whole her findings of earlier and stronger development of social interests on the part of social scientists were upheld by this study. Whether or not this interest in people and social things on the part of the psychologists is due to the lack of affection between them and their parents, and their consequent rebellion against their parents (as found by Roe and supported by this study), is unknown.

General Comments. It should be kept in mind that the central problem of investigation in this study as well as Roe's (1953a) and Cattell and Drevdahl's (1955) has been the measurement of differences between highly creative scientists and various control groups. Since less emphasis has been placed on measuring differences between scientific disciplines, less care taken in selecting samples, etc., the comparisons of the research findings relevant to this topic are less meaningful than those of creative compared with control scientists and should be viewed in this light.

Scientists Compared with the General Population

Table 16 lists the factors found by Cattell and Drevdahl (1955) to be characteristic of scientists when compared with the general United States' male population. The present study offers support to the findings that creative scientists are more introspective and more self-sufficient than the average man (Factors F and Q_2). The findings not supported may again be due to the reasons cited in the previous section.

Concluding Comments and Suggestions for Further Research

The studies to date indicate the typical creative scientist to be an extremely strongly motivated man (Biographical Factors) who needs no pushing but rather is self-propelled (Ghiselli Initiative Scale), dominating others to gain his desired outcome (Factor E) and being completely engrossed in his work to the exclusion of social and civic interests, with evidently no need for religion in his life (Biographical Factors). Yet this same man, who apparently is not "well rounded," is neither insecure nor unhappy (Maslow Security-Insecurity Inventory), but rather gains a great deal of enjoyment from his work (Biographical Factors). Personality differences between creative men in different scientific fields are less striking.

Research in this field is badly needed in the area of development

Table 16. Comparison of scientists and (male) population norms:[a] findings on personality characteristics

Characteristic	Investigator(s) and measuring instruments	Present study and measuring instruments
Scientists more dominant	Cattell and Drevdahl (1955)--Factor E, 16 P. F. Questionnaire	Not supported--Factor E, 16 P. F. Questionnaire
Scientists more introspective	Cattell and Drevdahl (1955)--Factor F, 16 P. F. Questionnaire	Supported--Factor F, 16 P. F. Questionnaire
Scientists more adventurous	Cattell and Drevdahl (1955)--Factor H, 16 P. F. Questionnaire	Not supported--Factor H, 16 P. F. Questionnaire
Scientists more self-sufficient	Cattell and Drevdahl (1955)--Factor Q_2, 16 P. F. Questionnaire	Supported--Factor Q_2, 16 P. F. Questionnaire

[a]Cattell and Stice (1957).

and validation of tests of such factors as persistence, energy level, and other characteristics hypothesized by leading researchers in the area as possibly differentiating the highly creative from the less creative researcher. Intelligence, as measured by such global tests as developed by David Wechsler, should be further considered, since studies in this area to date have resulted in a great deal of confusion regarding the relationship of such factors to research creativity. Also, the possibility of combining validated measures such as the above into predictive batteries should not be overlooked, since there is a strong need for improvement in techniques in the areas of research grant awards, selection of scientists for research work in industry, and the like. Finally, every effort should be made to attack the central problem in this area--i.e., what are the well-springs for the strong motivation of the creative researcher?

Chapter V. Summary

This study is concerned with the personal traits differentiating highly creative research scientists from less creative ones, with those distinguishing psychologists from chemists, and with those biographical factors in the scientists' lives which are important in determining the choice of profession within science, and achievement of creative productivity within the profession.

In order to investigate these areas, a questionnaire was developed covering areas suggested by previous research by Roe (1953a), Cattell and Drevdahl (1955), and others. The questionnaire, composed of a Biographical Inventory developed by the investigator, five factors from Cattell and Stice's (1957) 16 P. F. Questionnaire, items from Maslow's (1952) Security-Insecurity Inventory, and the Initiative Scale from Ghiselli's (1955) Self-Description Inventory, was mailed to approximately 740 U. S. male scientists (400 chemists and 340 psychologists). Within each profession one half was chosen on the basis of having achieved eminence as research scientists, as recognized through membership in the National Academy of Sciences or American Philosophical Society, being starred in American Men of Science, or similar evidence of national recognition for research. The other half was chosen from the membership lists of the professional societies of the disciplines, and each individual in this second group was chosen so as to match an

individual in the first group on the bases of age, sex, discipline, amount of education, and opportunity for research. No member of this second group, however, had achieved eminence or had become noted for distinguished research.

Sixty per cent of the forms were returned (438 usable forms). Comparisons were then made between creative and control scientists and psychologists and chemists. From other published results, scientists were compared with the general U. S. adult male population, as well as a male college student sample.

Creative scientists, regardless of discipline, were found to be more dominant (16 P. F., Factor E) and to have stronger initiative (Ghiselli Initiative Scale) than the less creative ones. The creative groups also appeared much more strongly motivated toward intellectual success as evidenced both by current research and other professional activities and by past performance in graduate, undergraduate, and high school (Biographical Factors).

Some significant differences were also found between psychologists and chemists, indicating psychologists to be more bohemian introverted, unconventional, imaginative, and creative in their thinking and behavior than chemists (16 P. F., Factor M). Differences were also found relating to factors in the earlier lives of the scientists.

In relation to students and the general male population, the scientists were found to be more silent and introspective (16 P. F., Factor F), but also more self-sufficient and resourceful (16 P. F., Factor Q_2).

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Appendix

Questionnaire Used in the Study

MICHIGAN STATE UNIVERSITY
EAST LANSING

Department of Psychology

RESEARCH ON SCIENTIFIC CREATIVITY

Jack A. Chambers
Principal Investigator

The form referred to in the letter (which you should have received several days ago) appears on the following pages. Each part contains its own instructions. It will take about one-half hour to complete it.

When you have finished, look back over the pages to make sure you have completed all the items, then seal the form in the enclosed stamped envelope, and mail it to me.

As mentioned in the earlier letter, you are not to indicate your name anywhere on the pages, thus assuring anonymity of response. In addition, the names of those scientists contacted to serve as subjects will not be published, and results will be cast in group form only.

If you would like to receive a brief report of the research results, be sure to mail the post card which was enclosed in the earlier letter, and you will receive a copy when it becomes available.

Your time and effort spent in connection with this research project are genuinely appreciated.

BIOGRAPHICAL INFORMATION

Please answer the following questions by MARKING AN X through the letter on the right hand side of the page which corresponds to that statement which most closely fits your individual case. MARK ONLY ONE RESPONSE PER ITEM. Do not omit a question unless it definitely does not apply to you, and please answer the questions as accurately as possible.

PERSONAL DATA

1. When I was married (for the first time, if married more than once) my age was: (a)Between 15 and 21 (b)Between 21 and 24 (c)Between 24 and 27 (d)Between 27 and 30 (e)30 or over — a b c d e

2. I would say that my wife's interests are predominantly: (a)Social (b)Intellectual or professional (c)Religious (d)Other — a b c d

3. My religious preference is: (a)Protestant (b)Catholic (c)Jewish (d)Other (e)No preference — a b c d e

4. I would classify my interest in religion as: (a)Strong (b)Moderate (c)Little (d)None (e)Opposed to religion — a b c d e

5. I have one or more hobbies to which I devote: (a)A little time (b)A fair amount of time (c)A great deal of time (d)As much time as possible (e)I have no hobbies — a b c d e

6. When I get any free time: (a)I enjoy watching or participating in sports most of all (b)I enjoy outdoor activities (other than sports) most of all (c)I enjoy indoor, individual activities most of all (d)I enjoy social activities most of all — a b c d

7. In my free hours, other than the time I spend on professional literature, I read: (a)Almost all the time (b)A great deal of the time (c)Some of the time (d)Little (e)Practically not at all — a b c d e

8. I would classify my commitments in civic and community activities as: (a)Quite heavy (b)Moderate (c)Light (d)None — a b c d

9. My present feelings towards my parents (or feelings prior to their deaths, if deceased) could well be expressed as: (a)Considerable love and affection (b)High regard (c)Sincere admiration for father, affection for mother (d)Relatively indifferent (e)Wish I could accept their behavior toward me with good grace but find it difficult — a b c d e

GRADUATE SCHOOL DATA

Please answer all questions concerning schools (i.e., costs, relative size of faculty, etc.) in the light of the conditions that prevailed at the time in which you were in attendance. If you attended more than one graduate, undergraduate, or high school, interpret the questions as applying to the school at which you took the majority of your training in each case (i.e., graduate, undergraduate, and high school).

10. My graduate grade point average was: (a)A (b)A minus (c)B plus (d)B (e)B minus or less — a b c d e

11. While in graduate school I devoted the following approximate amounts of time each week during the school year to my studies or to related research (include time spent in classes): (a)30 hours or less (b)31 to 40 hours (c)40 to 50 hours (d)50 to 65 hours (e)65 hours or over — a b c d e

12. While in graduate school, I had the following number of scientific articles published: (a)None (b)One (c)Two (d)Three (e)Four or more — a b c d e

13. My expenses in graduate school were met largely through: (a)Scholarships or Fellowships (b)Assistantships (c)Own savings or part-time work (d)Parents (e)Other — a b c d e

UNDERGRADUATE DATA

14. The religious affiliation of the undergraduate school I attended was: (a)Protestant (b)Catholic (c)Jewish (d)Other (e)None — a b c d e

15. Attendance costs at the school, in relation to other undergraduate schools, were: (a)Quite high (b)Fairly high (c)Average (d)Below average — a b c d

16. The student-to-faculty ratio at my undergraduate school was: (a)High (Small faculty in relation to size of student body) (b)Average (c)Low (Large faculty in relation to size of student body) — a b c

17. Emphases at my undergraduate school were placed on: (a)Intellectual pursuits, but also to some extent on social and athletic activities (b)Intellectual pursuits predominantly, with special attention given to insuring that the students became thoroughly familiar with the main bodies of knowledge in the sciences and humanities (c)Developing each student into a scholar by encouraging individual research achievement and giving individual help rather than relying primarily on regular classroom procedures (d)Other than the above — a b c d

18. The department in which I took my undergraduate major: (a)Had a departmental club, of which I was a member (b)Had a departmental club, but I did not join it (c)Had no departmental club — a b c

19. In my opinion, my undergraduate department, as compared to other departments in the school, had: (a)Severe requirements (b)Fairly stiff requirements (c)Moderate requirements (d)Light requirements (e)Very easy requirements — a b c d e

20. As an undergraduate I lived most of the four years: (a)At home with my parents (b)At a fraternity house (c)In a college dormitory (d)In off-campus rented rooms or apartment (e)Other — a b c d e

21. My overall undergraduate grade point average was: (a)A (b)A minus (c)B plus (d)B (e)B minus or less — a b c d e

22. My undergraduate grade point average in my major subject was: (a)A (b)A minus (c)B plus (d)B (e)B minus or less — a b c d e

23. During college I was a member of: (a)More than two honor societies (b)Two honor societies (c)One honor society (d)No honor societies — a b c d

24. My expenses in undergraduate school were met largely through: (a)Scholarships (b)Parents (c)Own savings or part-time work (d)Other — a b c d

25. Considering my undergraduate college expenses other than those met through scholarship aid, I paid the following percentage of them through my own efforts: (a)Less than 25% (b)25% to 50% (c)50% to 75% (d)75% or more — a b c d

26. When I received my undergraduate degree I was: (a)Over 22 (b)22 (c)21 (d)20 (e)Under 21 — a b c d e

HIGH SCHOOL DATA

27. During my high school years I spent the majority of my free time: (a)Dating or running around with "the gang" (b)Reading or studying (c)Participating in various sports (d)In connection with my hobbies (e)Other — a b c d e

28. In high school I participated in: (a)No clubs (b)One club (c)Two or three clubs (d)Four or more clubs — a b c d

29. In high school I: (a)Was not a member of any athletic teams (b)Was active in one or two sports (C)Was quite active in sports — a b c

30. I began dating when I was: (a)23 or over (b)20 to 22 (c)17 to 19 (d)14 to 16 (e)13 or under — a b c d e

31. In high school I felt: (a)Accepted by my classmates (b)Indifferent to my classmates (c)Somewhat rejected by my classmates (d)Somewhat superior to my classmates socially (e)Somewhat inferior to my classmates socially — a b c d e

32. As an adolescent I had the feeling of being isolated or apart from others: (a)Never (b)Occasionally (c)Sometimes (d)Much of the time (e)Most of the time — a b c d e

33. In high school my favorite subject was: (a)Mathematics, Chemistry, or Physics (b)English, Foreign languages, or social studies (c)Technical subjects (d)Other — a b c d

34. My work in high school mathematics was considered: (a)Outstanding (b)Good (c)Fair (d)Poor — a b c d

35. When I graduated from high school I was: (a)19 or older (b)18 (c)17 (d)16 (e)under 16 a b c d e

CHILDHOOD AND FAMILY DATA

36. In the family in which I was raised, I was one of the following number of children: (a)One (b)Two (c)Three (d)Four (e)Five or more a b c d e

37. My position in the family was: (a)Oldest child (b)Oldest son, but not oldest child (c)About the middle (d)Youngest child (e)Only child a b c d e

38. I had the following number of older brothers: (a)None (b)One (c)Two (d)Three or four (e)Five or more a b c d e

39. My older brother who was closest to me in age was: (a)One year or less older than I (b)Between one and two years older than I (c)Between two and three years older than I (d)Three or more years older than I (e)Did not have an older brother a b c d e

40. My father's education: (a)Doctorate degree the highest earned degree (b)Master's degree the highest earned degree (c)Bachelor's degree the highest earned degree (d)Some college, but no degree (e)High school education or less a b c d e

41. My father's occupation: (a)Professional (b)Business Executive (c)Farmer (d)Factory or office worker (e)Other a b c d e

42. My father: (a)Is/was always interested in outdoor activities in preference to indoor (b)Is/was always more interested in reading or other indoor activities than in outdoor activities a b

43. When I was a child, our family lived: (a)On a farm (b)In a rural village (c)In a small town or small city (d)In a large city (e)In a suburb of, or near a large city a b c d e

44. When I was a child, the house I lived in was located in the: (a)Northeast (b)Midwest (c)South (d)Far West (e)Foreign country a b c d e

45. I would describe the economic level of the home in which I was raised as: (a)Comparatively poor (b)Moderate circumstances (c)Well off a b c

46. The religious leanings in the home in which I was raised would be classified as: (a)Protestant (b)Jewish (c)Catholic (d)Other (e)None a b c d e

47. I would describe the family in which I was raised as: (a)Closely knit (b)Lacking in warmth (c)Individualistic, i.e., each person went his own way a b c

48. The attitude of my parents towards their children during the time I was growing up was: (a)More democratic than authoritarian (b)More authoritarian than democratic a b

49. As a child, my parents: (a)Dominated and/or over-protected me (b)Encouraged me to do things on my own (c)Were primarily concerned with their own affairs (d)Did not accept me or give me as much attention as I felt I needed (e)None of the above a b c d e

50. As a child, I felt that my parents: (a)Loved me a great deal (b)Were kind and considerate of me (c)Were warm and affectionate towards me (d)Were fine individuals, and that my father was a successful person (e)None of the above a b c d e

51. When I was a child, I: (a)Rebelled against my parents (b)Accepted the discipline of my parents, but was inwardly rebellious against it (c)Accepted the discipline of my parents without being too concerned about it (d)Wished that my parents would be more strict with me (e)None of the above a b c d e

52. In my childhood there was: (a)More than moderate affection and understanding between my father and me (b)Average affection and understanding between my father and me (c)Less than moderate affection and understanding between my father and me (d)Practically no affection and understanding between my father and me a b c d

53. My parents, in raising me, stressed: (a)Good manners and appropriate clothing (b)The Golden Rule (c)That I should always work hard, and be honest and trustworthy (d)That I should do what they say and always respect my elders (c)None of the above a b c d e

54. As far back as I can remember, I was allowed a good deal of freedom in choosing my friends, clothing, food, etc. (a)Completely true (b)Mostly true (c)Partially true, partially false (d)Mostly false (e)Completely false a b c d e

55. Before the age of 10: (a)One or more of my parents had died (b)My parents had separated or divorced (c)I had been seriously ill (d)Any combination of the above (e)None of the above a b c d e

56. In the home in which I was raised, education and learning: (a)Were not especially valued (b)Were valued for their own sake (c)Were valued as investments for future security (d)Were valued in the light of the aid they provide in achieving financial success and/or social prestige (e)None of the above a b c d e

57. When I was in the upper grades, I read: (a)Only when required (b)A book now and then (c)Several books a month (d)One or two books a week (e)More than two books a week a b c d e

58. In grade school, I felt different, or somewhat apart from others: (a)Never (b)Occasionally (c)Sometimes (d)Much of the time (e)Most of the time a b c d e

59. I felt that my family: (a)Was different from others (b)Was somewhat superior to others (c)Neither of the above — a b c

VOCATIONAL DATA

60. I chose my profession: (a)When I was in graduate school (b)During my junior or senior year in undergraduate school (c)During my freshman or sophomore year in undergraduate school (d)When I was in high school (e)Prior to entering high school — a b c d e

61. Concerning research as a career or major interest: (a)I "drifted" into it (b)I chose it — a b

62. I first chose or accepted research as a career or major interest: (a)After leaving graduate school (b)When I was in graduate school (c)When I was an undergraduate (d)When I was in high school (e)Prior to entering high school — a b c d e

63. I chose my occupation predominantly: (a)On the basis of my preference and that of my parents (b)On the basis of my preference alone (c)Because of the influence of one or more of my teachers (d)Other — a b c d

64. On the average, I keep up with the articles in: (a)No scientific journals (b)One or two scientific journals (c)Three or four scientific journals (d)Five or six scientific journals (e)More than six scientific journals — a b c d e

65. I am a member of the following number of professional organizations: (a)None (b)One or two (c)Three or four (d)Five or six (e)More than six — a b c d e

66. I attend the following approximate number of professional conventions each year: (a)None (b)One or two (c)Three or four (d)Five or six (e)More than six — a b c d e

67. I deliver a paper at a professional convention: (a)Rarely or never (b)Every year or so (c)At least once a year (d)Two or three times a year (e)Four or more times a year — a b c d e

68. My opinion concerning most professional conventions is that: (a)They are professionally stimulating and therefore of value (b)They are sometimes interesting and sometimes a waste of time (c)They are of primary value to the socially oriented individual and of lesser value to research oriented individuals — a b c

69. I spend the following approximate number of hours weekly in connection with my work (including time spent both at my place of employment and elsewhere): (a)30 or less (b)31 to 40 (c) 40 to 50 (d)50 to 65 (e)65 or over — a b c d e

70. I believe that I do my best research when: (a)I work alone (b)I work as a member of a group — a b

71. In relation to my work, I: (a)Am completely happy only when working (b)Get a great deal of satisfaction from it (c)Get some satisfaction from it (d)Am not too happy with my vocational choice (e)Wish I had gone into another field — a b c d e

72. Administrative aspects of scientific work: (a)Interest me a great deal (b)Are moderately interesting to me (c)Are of little interest to me (d)Are of no interest to me — a b c d

73. In research work, I believe that working hours should be: (a)Standard, i.e., a regular eight hour day (b)Flexible, so as to permit workers some freedom in choosing working hours (c)Set by the individual alone — a b c

74. Ideally, I think that the following number of hours per week should be spent in active research at the place of employment if creative output is to be at a maximum: (a)Less than 20 (b)20 to 30 (c)30 to 35 (d)35 to 40 (e)More than 40 — a b c d e

75. In research work, work deadlines: (a)Should be set by a superior (b)Should be set by the individual or group concerned (c)Should not be set at all — a b c

76. Concerning professional positions, the most important one of the following factors, in my opinion, is: (a)Opportunity for permanent work and for advancement (b)Stimulating associates and atmosphere conducive to research (c)Opportunity to combine research work with teaching or administrative duties (d)Opportunity to do really creative research and to choose problems of interest to me — a b c d

CLASSIFICATION DATA

Please fill in the blanks.

77. My age to nearest birthday is: _____ years.

78. My highest earned degree is at the level of (doctorate, master's or bachelor's): _____.

79. My area of specialization is (indicate experimental psychology, clinical psychology, biochemistry, etc.): _____.

80. I have the following number of scientific products to my credit:

_____ number of published scientific articles (include joint publications)

_____ number of published scientific books (include edited books and joint publications)

_____ number of patents (include only patents that have been issued in your name or jointly with others)

81. To date, I have spent the majority of my professional life working in the following type of setting: (indicate industrial, educational, government or other):_____

FACTOR INVENTORY*

On the following pages you will find a number of statements. Please read each one carefully, and then choose that response, from the three available, that most closely fits your individual case. Indicate your choice by MARKING AN X through the letter on the right hand side of the page that corresponds to your preferred response. PLEASE MARK ONLY ONE RESPONSE PER ITEM. You will note that some questions permit a"?" response. This should be used only if you are unable to decide between the other two choices

1. I believe it is right to understate how good I am at something, when people ask. (a)Yes (b)In between (c)No	a	b	c
2. I make smart, sarcastic remarks to people if I think they deserve it. (a)Generally (b)Sometimes (c)Never	a	b	c
3. I get on better with people who: (a)Keep an open mind and refuse to come to an early conclusion (b)Are in between (a) and (c) (c)Know exactly what their own opinions are	a	b	c
4. I prefer to marry someone who: (a)Commands general admiration (b)In between (c)Has artistic and literary gifts	a	b	c
5. I sometimes get an unreasonable dislike for a person: (a)But it is so slight I hide it easily (b)In between (c)Which is so definite that I tend to express it	a	b	c
6. In constructing something I would rather work: (a)With a committee (b)Uncertain (c)On my own, perhaps with one or two assistants	a	b	c
7. I doubt my ability to do ordinary things as well as other people (a)Generally (b)Often (c)Occasionally	a	b	c
8. I tend to feel nervous and harried in the presence of business superiors. (a)Yes (b)In between (c)No	a	b	c
9. I sometimes make rash remarks in fun, just to surprise people and see what they will say. (a)Yes (b)In between (c)No.	a	b	c
10. I like a friend (of my sex) who: (a)Seriously thinks out his attitudes to life (b)In between (c)Is efficient and practical in his interests	a	b	c
11. My deeper moods sometimes make me seem unreasonable, even to myself. (a)Yes (b)In between (c)No	a	b	c
12. When I was about fourteen and fifteen, I joined in school sports: (a)Occasionally (b)Fairly often (c)A great deal	a	b	c
13. I have some characteristics in which I feel superior to most people. (a)Yes (b)Uncertain (c)No	a	b	c
14. I have no objection to a job that involves my looking soiled and messy all day. (a)Yes (b)In between (c)No	a	b	c
15. I tend toward: (a)A rather reckless optimism (b)In between (c)An overcautious pessimism	a	b	c
16. My memory tends to drop a lot of unimportant, trivial things, for example, names of streets or shops in town (a)Yes (b)In between (c)No.	a	b	c
17. I prefer to marry someone who can: (a)Keep the family interested in its own activities (b)In between (c)Make the family part of the social life of the neighborhood.	a	b	c
18. One can hardly do a thing these days without being regulated or exploited by "big business" or government agencies. (a)Yes (b)In between (c)No	a	b	c
19. The use of foul language, even if not in a mixed group of men and women, still disgusts me. (a)Yes (b)In between (c)No	a	b	c
20. I have decidedly fewer friends than most people. (a)Yes (b)In between (c)No	a	b	c
21. If people on a team (or anything else) I am managing will just follow ordinary instructions, I will guarantee its performance (a)Yes (b)In between (c)No	a	b	c
22. I like continually to have to learn to work new gadgets in everyday things, from can openers to cars (a)Yes (b)Uncertain (c)No	a	b	c
23. One should be careful about mixing with all kinds of strangers, for there are dangers of infection and other things (a)Yes (b)Uncertain (c)No	a	b	c
24. When I was about seventeen or eighteen I went out with the opposite sex: (a)A lot (b)As much as most people (c)Very little	a	b	c

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25. I like to take an active part in social affairs, committee work, etc. (a)Yes (b)In between (c)No a b c

26. I think I am better described as: (a)Polite and quite (b)In between (c)Lively and active a b c

27. I feel some of my gifts have never been expressed enough for people to recognize them. (a)Yes (b)In between (c)No a b c

28. I like to go out to a show or entertainment: (a)Less than once a week (less than average) (b)About once a week (average) (c)More than once a week (more than average) a b c

29. My artistic feelings sometimes outweigh common sense. For example, I would not live in a wrongly-decorated apartment even if it saved money. (a)True (b)Uncertain (c)False a b c

30. I like to: (a)Be free of personal entanglements (b)In between (c)Have a circle of warm friendships, even if they are demanding a b c

31. It bothers me if people think I am being too unconventional or odd. (a)A good deal (b)Somewhat (c)Not at all a b c

32 Most people would be happier if they lived more with their fellows and did the same things as others. (a)Yes (b)In between (c)No a b c

33. I occasionally tell strangers about the things I am interested in and good at, without direct questions from them. (a)Yes (b)In between (c)No a b c

34. I spend much of my spare time talking with friends over social events enjoyed in the past. (a)Yes (b)In between (c)No a b c

35. I enjoy doing "daring" foolhardy things "just for fun". (a)Yes (b)In between (c)No a b c

36. The teaching of different beliefs about right and wrong is: (a)Always interesting (b)Something we cannot avoid (c)Unpleasant and wasteful a b c

37. I am always interested in mechanical matters--for example, in cars and airplanes. (a)Yes (b)In between (c)No a b c

38. I like to do my planning alone, without interruptions and suggestions from others. (a)Yes (b)In between (c)No a b c

39. If the odds are really against something's being a success, I still believe in taking the risk. (a)Yes (b)In between (c)No a b c

40. I like it when I know so well what the group has to do that I naturally become the one in command. (a)Yes (b)In between (c)No a b c

41. I prefer to dress: (a)Very quietly and correctly (b)In an average way (c)With a bit of definite style that people can see a b c

42. I enjoy more an evening: (a)With a good hobby of my own (b)Uncertain (c)In a lively party a b c

43. Talk with ordinary, habit-bound, conventional people: (a)Is often quite interesting (b) In between (c)Annoys me because it is superficial and insensitive a b c

44. I find it embarrassing to have praise or compliments bestowed on me (a)Yes (b)In between (c)No a b c

45. I learn better by: (a)Reading a well-written book (b)In between (c)Joining a group discussion a b c

46. I have sometimes been described as a rather headstrong person, following my own ideas regardless of the opinions of others. (a)Yes (b)In between (c)No a b c

47. I think I am better at showing: (a)Courage in meeting challenges (b)Uncertain (c)Tolerance of other's views a b c

48. I am generally considered a lively, enthusiastic person. (a)Yes (b)In between (c)No a b c

49. I like a job that offers change, variety, and travel, even if it involves some danger. (a)Yes (b)In between (c)No a b c

50. Are you easily hurt? (a)Yes (b)? (c)No a b c

51. On social occasions I: (a)Readily come forward and speak (b)Respond in between (c)Prefer to stay quietly in the background a b c

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52. Do you feel at home in the world? (a)Yes (b)? (c)No a b c

53. Do you worry about your intelligence? (a)Yes (b)? (c)No a b c

54. I get slightly embarrassed if I suddenly become the focus of attention in a social group. (a)Yes (b)In between (c)No a b c

55. Do you generally put others at their ease? (a)Yes (b)? (c)No a b c

56. I am always glad to join a large gathering, for example, a party, dance, or public meeting. (a)Yes (b)In between (c)No a b c

57. Do you have a vague fear of the future? (a)Yes (b)? (c)No a b c

58. Do you behave naturally? (a)Yes (b)? (c)No a b c

59. I tend to keep quiet in the presence of senior persons(people of greater experience, age, or rank) (a)yes (b)In between (c)No a b c

60. Do you feel you are generally lucky? (a)Yes (b)? (c)No a b c

61. I find it hard to address, or recite to, a large group. (a)Yes (b)In between (c)No a b c

62. Did you have a happy childhood? (a)Yes (b)? (c)No a b c

63. Do you have many real friends? (a)Yes (b)? (c)No a b c

64. My reserve always stands in the way when I want to speak to an attractive stranger of the opposite sex. (a)Yes (b)In between (c)No a b c

65. Do you feel restless most of the time? (a)Yes (b)? (c)No a b c

66. I would rather have a job with: (a)A fixed, certain salary (b)In between (c)A larger salary, but dependent on my constantly persuading people I am worth it a b c

67. Do you tend to be afraid of competition? (a)Yes (b)? (c)No a b c

68. Is your home environment happy? (a)Yes (b)? (c)No a b c

69. I have at least as many friends of the opposite sex as of my own sex. (a)Yes (b)In between (c)No a b c

70. Do you worry too much about possible misfortune? (a)Yes (b)? (c)No a b c

71. Even in an important game, I am more concerned to enjoy it than to win it. (a)Always (b)Generally (c)Occasionally a b c

72. Do you often become very annoyed with people? (a)Yes (b)? (c)No a b c

73. Do you ordinarily feel contented? (a)Yes (b)? (c)No a b c

74. I consider myself a very sociable, talkative person. (a)Yes (b)In between (c)No a b c

75. Do your moods tend to alternate from very happy to very sad? (a)Yes (b)? (c)No a b c

76. In social contacts I: (a)Express my emotions very readily (b)In between (c)Keep my emotions to myself a b c

77. Do you feel that you are respected by people in general? (a)Yes (b)? (c)No a b c

78. Are you able to work harmoniously with others? (a)Yes (b)? (c)No a b c

79. Do you feel you can't control your feelings? (a)Yes (b)? (c)No a b c

80. I somewhat dislike having a group watching me at work. (a)Yes (b)In between (c)No a b c

81. Do you sometimes feel that people laugh at you? (a)Yes (b)? (c)No a b c

82. Are you generally a relaxed person (rather than tense)? (a)Yes (b)? (c)No a b c

83. On the whole do you think you are treated right by the world? (a)Yes (b)? (c)No a b c

84. I don't believe in persuading friends to go out if they just want to sit around at home. (a)True (b)In between (c)False a b c

85. Are you ever bothered by a feeling that things are not real? (a)Yes (b)? (c)No a b c

86. Have you often been humiliated? (a)Yes (b)? (c)No a b c

87. Do you think you are often regarded as queer? (a)Yes (b)? (c)No a b c

SELF-DESCRIPTION INVENTORY **

The purpose of the following items is to obtain a picture of the traits you believe you possess, and to see how you discribe yourself. There are no right or wrong answers so try and describe yourself as accurately and honestly as you can.

Below are listed 32 pairs of traits. Choose one trait from each pair which you think is MOST descriptive of you, and INDICATE YOUR CHOICE BY MARKING AN X THROUGH THE LETTER TO THE LEFT OF IT. PLEASE MARK ONLY ONE RESPONSE PER ITEM.

1.	(a)Capable (b)Discreet	9.	(a)Industrious (b) Practical	17.	(a)Affectionate (b)Frank	25.	(a)Responsible (b)Reliable
2.	(a)Understanding (b)Thorough	10.	(a)Planful (b)Resourceful	18.	(a)Progressive (b)Thrifty	26.	(a)Dignified (b)Civilized
3.	(a)Cooperative (b)Inventive	11.	(a)Unaffected (b)Alert	19.	(a)Sincere (b)Calm	27.	(a)Imaginative (b)Self-controlled
4.	(a)Friendly (b)Cheerful	12.	(a)Sharp-witted (b)Deliberate	20.	(a)Thoughtful (b)Fair-minded	28.	(a)Conscientious (b)Quick
5.	(a)Energetic (b)Ambitious	13.	(a)Kind (b)Jolly	21.	(a)Poised (b)Ingenious	29.	(a)Logical (b)Adaptable
6.	(a)Persevering (b)Independent	14.	(a)Efficient (b)Clear-thinking	22.	(a)Sociable (b)Steady	30.	(a)Sympathetic (b)Patient
7.	(a)Loyal (b)Dependable	15.	(a)Realistic (b)Tactful	23.	(a)Appreciative (b)Good-natured	31.	(a)Stable (b)Foresighted
8.	(a)Determined (b)Courageous	16.	(a)Enterprising (b)Intelligent	24.	(a)Pleasant (b)Modest	32.	(a)Honest (b)Generous

In each of the pairs of words below, MARK AN X THROUGH THE LETTER TO THE LEFT OF THE WORD WHICH YOU THINK IS LEAST DESCRIPTIVE OF YOU.

33.	(a)Shy (b)Lazy	41.	(a)Conceited (b)Infantile	49.	(a)Careless (b)Foolish	57.	(a)Opinionated (b)Pessimistic
34.	(a)Ambitious (b)Reckless	42.	(a)Shallow (b)Stingy	50.	(a)Apathetic (b)Egotistical	58.	(a)Shiftless (b)Bitter
35.	(a)Noisy (b)Arrogant	43.	(a)Unstable (b)Frivolous	51.	(a)Despondent (b)Evasive	59.	(a)Hard-hearted (b)Self-pitying
36.	(a)Emotional (b)Headstrong	44.	(a)Defensive (b)Touchy	52.	(a)Distractible (b)Complaining	60.	(a)Cynical (b)Aggressive
37.	(a)Immature (b)Quarrelsome	45.	(a)Tense (b)Irritable	53.	(a)Weak (b)Selfish	61.	(a)Dissatisfied (b)Outspoken
38.	(a)Unfriendly (b)Self-seeking	46.	(a)Dreamy (b)Dependent	54.	(a)Rude (b)Self-centered	62.	(a)Undependable (b)Resentful
39.	(a)Affected (b)Moody	47.	(a)Changeable (b)Prudish	55.	(a)Rattle-brained (b)Disorderly	63.	(a)Shy (b)Excitable
40.	(a)Stubborn (b)Cold	48.	(a)Nervous (b)Intolerant	56.	(a)Fussy (b)Submissive	64.	(a)Irresponsible (b)Impatient

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LOOK BACK OVER THE PAGES AND MAKE SURE YOU HAVE COMPLETED ALL OF THE ITEMS