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Considerable evidence exists to suggest the notion that selected personality traits may be related to specific aspects of academic achievement. This study was directed toward the investigation of this relationship in the case of non-science majors enrolled in a college course in physical science.

Personality was assessed with the California Psychological Inventory (CPI) and academic achievement was defined in terms of the subjects' performance on the examinations regularly administered for grading purposes in the course, i.e., the "midterm" and final examinations. Two aspects of academic achievement were measured by classifying all examination questions as either verbal or numerical. Examination questions were classified as "numerical" whenever the use of mathematics was a necessary requisite in selecting the correct response to an item, and verbal if they were not numerical.

The population consisted of the students enrolled in the two sections of General Science 104 at Oregon State University during the fall term of 1966. The population was subdivided into four groups on the basis of sex and lecture section. Two hypotheses were tested in each of the four population subdivisions.

A - There is no significant correlation between verbal achievement and personality; and there is no significant correlation between numerical achievement and personality.

B - There is no significant correlation between the ratio of numerical achievement to verbal achievement and personality.

In three out of four cases A was rejected, leading to the conclusion that personality and achievement in physical science are related. For males, five CPI scales correlated with achievement in physical science at the .05 level. Four of them were related to verbal achievement and one was related to numerical achievement. Among the females, eleven significant correlation coefficients occurred between CPI scales and achievement in physical science. Six of them were related to verbal achievement and five to numerical achievement.

B was accepted in all four null tests, but further interpretation of the results led to the conclusion that discrepant achievement, the ratio of numerical achievement to verbal achievement, is related to personality.

The implications of this study relative to current public school science curricula were discussed. The need for further research based upon a theory of discrepant achievement was considered in light of its relevance to the problem of achievement in physical science.

VERBAL-NUMERICAL ACHIEVEMENT IN A REQUIRED COLLEGE PHYSICAL SCIENCE COURSE AND SOME PERSONALITY CORRELATES

by

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

VERBAL-NUMERICAL ACHIEVEMENT IN A REQUIRED COLLEGE PHYSICAL SCIENCE COURSE AND SOME PERSONALITY CORRELATES

I. INTRODUCTION

Background

The need to provide more effective science education in our present culture seems clearly evident from the magnitude and extent of recent science curriculum development efforts. Presently, there is a proliferation of well financed, large scale science curriculum projects directed at meeting this need. It is generally agreed that these curriculum projects have produced many noteworthy accomplishments including the creation of entirely new, excellent, and often quite rigorous text and laboratory materials. The essential thrust of these curriculum projects is usually directed toward the development of a highly structured and conceptually oriented treatment of the several fundamental notions embodied in a particular academic discipline. The major emphasis in these new science curricula is upon understanding as opposed to rote memory. The intent is that the student will acquire an understanding of the subject matter in terms of these several fundamental notions. In the classroom, much stress is placed on teaching techniques involving the use of open ended laboratory experiments, problem solving, inquiry, critical thinking and divergent or creative thinking.

The first of these new science curriculum development projects, the Physical Science Study Committee (PSSC), established a pattern which has seemed to prevail in virtually all subsequent projects and herein lies a potential danger. In this regard Sizer (1965, p. 192) notes:

> Unfortunately, however, and alas, inevitably curriculum development now runs the risk of being promoted as a panacea, and the manner in which the innovators started has been accepted by the unwary as perfection. Perhaps it behooves us to stand back and look at what we are doing and to try to see what needs yet to be done.

An outstanding illustration of Sizer's observation is represented by the subsequent experience of the PSSC physics program itself. In spite of the committee's efforts since 1957, to improve the high school physics curriculum, the percentage of secondary school students enrolling in physics has continued to decline. The effect of this enrollment decline upon curriculum development has been simply to motivate a second new physics curriculum improvement project, namely the Harvard Project Physics. The effect of this second physics project upon enrollment is not yet known.

The coincidence of enrollment decline and implementation of new science curricula in the secondary schools has not been confined solely to the discipline of physics. This same phenomena can be noted in chemistry and, at the junior high level, in general science, (Brent and Kronenberg, 1966, p. 238).

One result of these disturbing events has been the suggestion, from several quarters, that science educators may have overlooked several important factors in their efforts to produce high quality curricular materials. Among the numerous explanations offered in this regard, is that of Lehman (1967, p. 13) who has suggested that in the effort to increase the excellence of course content in the sciences, important sociological and psychological (non-intellectual) factors of the learner have been overlooked. He states the following:

> At this advanced stage in the development and revision of a whole host of new high school curricula in the sciences, it seems necessary to stop and to ask: Have we really considered the high school student, the adolescent, in preparing these programs?. . . as science educators we should be looking seriously at the findings of contemporary adolescent psychology and sociology and considering their implications for the teaching of science. . .

The suggestion that course content is only one of several important variables known to influence academic achievement is also implicit in the following statement by Cattell, Sealy and Sweney (1966, p. 280). They state that two such important non-cognitive variables which may significantly influence academic achievement are motivation and personality. In their words:

> The first half of this century saw a remarkable growth in the systematic understanding of human abilities, and of their predictive relation to various kinds of achievement. . . It may well be that the second half will be a parallel development in the use of measures of personality and motivation in predicting and understanding achievement.

The present investigation is restricted to a study of certain aspects of personality and their relationship to academic achievement in physical science. That investigations of this nature seem potentially fruitful is clearly evident in the following from Butcher and Ainsworth (1963, p. 276):

> Although it is widely recognized that personality factors play a part in determining the school attainment, methods of assessing them have in general proved disappointing. . . From a theoretical point of view, however, there are enough suggestive and interesting findings in the literature to make it clear that research is getting warm, so to speak, and that real effects are there to be discovered. . .

In the hope of making a useful contribution to the development of more effective curricula in science, this study focuses upon the relationship between personality and academic achievement in physical science.

Statement of the Problem

Most contemporary scientists and educators would agree that the role of science is of such fundamental importance in the improvement of mankind's condition, and the changes brought about by science can have such profound effects upon our cultural traditions, that every responsible citizen should possess some minimal knowledge of its methods, limitations, and important contributions. To this end, most colleges and universities in the United States require

certain minima in the study of science as part of the general education requirements for a Bachelor's degree. The most frequent means of providing for these requirements is to offer companion, survey courses in the physical and biological sciences designed especially for students who are not science majors.

An important consideration may be noted regarding required college level courses in the physical sciences. The intellectual demands made upon a student in such a course are somewhat different from those expected of him in a course of a primarily descriptive nature such as history or language, etc. The study of physical science is more likely to require of the student a certain facility in the application of elementary mathematics to the solution of simple problems, whereas in courses which tend to be descriptive, memory and verbal ability would seem to be the most important intellectual requirements.

It has been noted by Aiken (1963), Malone and Fred (1954), and others, that some students, who do excellent work otherwise, appear to experience considerable difficulty in reaching an understanding of quantitative concepts. This author's experience suggests that this difficulty can become a source of considerable anxiety within the students which in turn may result in negative attitudes toward physical science (Saunders, 1965). For example, consider the following responses which are typically representative of

students who were experiencing academic difficulty in the physical science course at Oregon State University.

> "I have to have this [course] but I've never done well in science am afraid I'm going to flunk."
>
> "I've never understood science but I have to get a C out of this course."
>
> "Science has always been one of my hardest classes."
>
> "This class scares me to death."
>
> "I don't understand anything that is going on. I've had no background and I'm absolutely lost."
>
> "I'm extremely interested in this class, but I am so in the dark I fear it tremendously. I know so little of math that I feel I have no chance of making it." (Saunders, 1965)

Considering these kinds of attitudes as educational outcomes, which indeed they are, it is disturbing when one compares them with the kinds of objectives most commonly associated with courses of this nature.

A typical and widely accepted objective for general education college level courses in physical science is "to understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems and to appreciate the implications of scientific discoveries." (President's Commission on Higher Education, 1947, p. 52)

It is reasonable to assume that with such troubled students, accomplishment of course objectives like the above is interfered with to a large extent by the student's fears and his desperate concern to pass the course satisfactorily.

The author's experience over the past three years in working very closely with students who are experiencing difficulties in physical science, suggests the possibility that personality and intellectual achievement may be related. Perhaps it is possible that in some individuals, certain aspects of personality may serve in some way to inhibit the necessary cognitive processes involved in dealing with quantitative concepts while enhancing those necessary for verbal and memory skills. Ausubel (1963, p. 46) suggests, for example, that individuals in a threatening situation tend to see rote learning as "easier" than "meaningful" learning. In his words:

> It should be noted, however, that although rote learning is more difficult than meaningful learning in most circumstances, it may actually be easier for the individual who lacks the necessary ideational background for a particular learning task. It often appears easier to the anxiety-ridden person who lacks confidence in his ability to understand difficult and unfamiliar new propositions.

Thus as a part of the continuing attempt to develop more effective programs in science education, this study focuses its attention upon an important aspect of the learning situation: that of the relationship between personality and achievement in physical science.

Personality and Achievement Defined

As alluded to on page 4 above, Butcher and Ainsworth indicate that there seems to be general agreement that personality is related

in some way, to academic achievement. However, the ability to identify specific modes of academic achievement in physical science which relate to well defined and reliably measurable aspects of personality, remains as yet an unattainable goal. It is toward this kind of objective that the present study takes its general direction.

In this study, a subject's personality was defined as a set of raw scores on a personality inventory, and achievement in physical science was defined in terms of the subject's raw score performance on mid-term and final examinations given in the respective courses.

The subject's personalities were assessed with the California Psychological Inventory (CPI). It purports to measure 18 aspects of "normal" individuals. These aspects with their respective abbreviations are: Dominance (Do), Capacity for Status (Cs), Sociability (Sy), Social Presence (Sp), Self-acceptance (Sa), Sense of Well-being (Wb), Responsibility (Re), Socialization (So), Self-control (Sc), Tolerance (To), Good Impression (Gi), Communality (Cm), Achievement via independence (Ai), Intellectual efficiency (Ie), Psychological-mindedness (Py), Flexibility (Fx), and Feminity (Fe). The descriptive interpretations of these 18 scales together with brief statements representative of high and low scorers are presented in Figure 1.

Achievement in physical science was considered from two aspects. Classification of midterm and final examination questions

Figure 1. Descriptive interpretation of the Eighteen Personality Traits assessed with the California Psychological Inventory

High scorers	Scale and purpose	Low scorers
CLASS I. MEASURES OF POISE, ASCENDANCY, AND SELF-ASSURANCE		
Aggressive, confident, persistent, planful; being persuasive and verbally fluent; self-reliant and independent; as having leadership potential.	1. Do (dominance) To assess factors of leadership ability, dominance, persistence, and social initiative.	Retiring, inhibited, commonplace, silent and unassuming; as being slow in thought and action; as avoiding situations of tension and decision; lacking self-confidence.
Ambitious, active, forceful, insightful and versatile; ascendant and self-seeking; effective in communication; having personal scope and breadth of interests.	2. Cs (capacity for status) To serve as an index of an individual's capacity for status (not his actual or achieved status). The scale attempts to measure the personality qualities and attributes which underlie and lead to status.	Apathetic, shy, conventional, dull, mild, simple, and slow; as being stereotyped in thinking; restricted in outlook and interests; being uneasy and awkward in new or unfamiliar social situations.
Outgoing, enterprising, ingenious, competitive, forward, original in thought.	3. Sy (sociability) To identify persons of outgoing, sociable, participative temperament.	Awkward, conventional, quiet, submissive; unassuming; detached and passive attitude; suggestible, and overly influenced by others' reactions and opinions.
Clever, enthusiastic, quick, informal, spontaneous, imaginative, talkative, active and vigorous, having an ebullient nature.	4. Sp (social presence) To assess factors such as poise, spontaneity, and self-confidence in personal and social interaction.	Deliberate, moderate, patient, simple; vacillating and uncertain; literal and unoriginal in thinking.
Intelligent, outspoken, sharp-witted, demanding, aggressive, self-centered, persuasive and verbally fluent, self-confident and self-assurance.	5. Sa (self-acceptance) To assess factors such as sense of personal worth, self-acceptance, and capacity for independent thinking and action.	Methodical, conservative, conventional, dependable, easygoing and quiet; self-abasing given to feelings of guilt and self-blame; passive in action and narrow in interest.

Continued on next page

Figure 1. (Continued)

High scorers	Scale and purpose	Low scorers
Energetic, enterprising, alert, versatile, productive and active; and as valuing work and effort for its own sake.	6. Wb (sense of well-being) To identify persons who minimize their worries and complaints, and who are relatively free from self-doubt and disillusionment.	Unambitious, leisurely, awkward, cautious, apathetic, and conventional, self-defensive, apologetic, constricted in thought and action.
CLASS II. MEASURES OF SOCIALIZATION, MATURITY, AND RESPONSIBILITY		
Planful, responsible, capable, thorough, progressive, dignified, independent, conscientious and dependable, resourceful, efficient, alert to ethical and moral issues.	7. Re (responsibility) To identify persons of conscientious, responsible, and dependable disposition and temperament.	Immature, moody, lazy, awkward, changeable, disbelieving, influenced by personal bias, and as under-controlled and impulsive in behavior.
Serious, honest, industrious, modest, obliging, sincere and steady; as being responsible and as being self-denying and conforming.	8. So (socialization) To indicate the degree of social maturity, integrity and rectitude which the individual has attained.	Defensive, demanding, opinionated, resentful, stubborn, headstrong, rebellious and undependable; guileful and deceitful, excess exhibition and ostentation in behavior.
Calm, patient, practical, slow, self-denying, inhibited, thoughtful and deliberate, strict and thorough in own work and in expectations of others; honest and conscientious.	9. Sc (self-control) To assess the degree and adequacy of self-regulation and self-control and freedom from impulsivity and self-centeredness.	Impulsive, shrewd, excitable, irritable, self-centered, uninhibited; aggressive and assertive; overemphasizing personal pleasure and self-gain.
Enterprising, informal, quick, clear-thinking, tolerant, resourceful, intellectually able and verbally fluent, varied interests.	10. To (tolerance) To identify persons with permissive, accepting, and non-judgment social beliefs and attitude.	Suspicious, narrow, aloof, wary, retiring, passive and overly judgmental in attitude, disbelieving and distrustful in outlook.
Co-operative, enterprising, out-going, sociable, helpful, being concerned with making a good impression, being diligent and persistent.	11. Gi (good impression) To identify persons capable of creating a favorable impression who are concerned with how others react to them.	Inhibited, cautious, shrewd, wary, aloof and resentful, cool and distant in relations with others; self-centered and little concerned with the needs and wants of others.

Continued on next page

Figure 1. (Continued)

High scorers	Scale and purpose	Low scorers
Dependable, moderate, tactful, reliable, sincere, patient, steady, and realistic; honest and conscientious; having common sense and good judgment.	12. Cm (communality) To indicate the degree to which an individual's reactions and responses correspond to the common pattern established for the inventory.	Impatient, changeable, complicated, imaginative, disorderly, nervous, restless, guileful and deceitful, inattentive and forgetful; having internal conflicts and problems.
CLASS III. MEASURES OF ACHIEVEMENT POTENTIAL AND INTELLECTUAL EFFICIENCY		
Capable, cooperative, efficient, organized, responsible, stable, and sincere; being persistent and industrious; valuing intellectual activity and intellectual achievement.	13. Ac (achievement via conformance) To identify those factors of interest and motivation which facilitate achievement in any setting where conformance is a positive behavior.	Coarse, stubborn, aloof, awkward, insecure and opinionated; easily disorganized under stress to conform; pessimistic about occupational futures.
Mature, forceful, strong, dominant, demanding, and foresighted; as being independent and self-reliant; and as having superior intellectual ability and judgment.	14. Ai (achievement via independence) To identify those factors of interest which facilitate achievement in any setting where autonomy and independence are positive behaviors.	Inhibited, anxious, cautious, dissatisfied, dull and wary, submissive and compliant before authority; lacking self-insight and self-understanding.
Efficient, clear-thinking, capable, intelligent, progressive, thorough, resourceful, being alert and well-informed; placing high value on cognitive and intellectual matters.	15. Ie (intellectual efficiency) To indicate the degree of personal and intellectual efficiency which the individual has attained.	Cautious, confused, easy-going, defensive, shallow and unambitious; as being conventional and stereotyped in thinking and as lacking self-direction and self-discipline.
CLASS IV. MEASURES OF INTELLECTUAL AND INTEREST MODES		
Observant, spontaneous, quick, perceptive, resourceful, changeable, verbally fluent and socially ascendant; rebellious toward rules, restrictions and constraints.	16. Py (psychological-mindedness) To measure the degree to which the individual is interested in, and responsive to, the inner needs, motives, and experiences of others.	Apathetic, peaceable, serious, cautious, unassuming; slow and deliberate in tempo; overly conforming and conventional.

Continued on next page

Figure 1. (Continued)

High scorers	Scale and purpose	Low scorers
Insightful, informal, adventurous, confident, humorous, rebellious, idealistic, assertive, and egotistic; sarcastic and cynical; highly concerned with personal pleasure and diversion.	17. Fx (flexibility) To indicate the degree of flexibility and adaptability of a person's thinking and social behavior.	Deliberate, cautious, worrying, industrious, guarded, mannerly, methodical, rigid; formal and pedantic in thought; overly deferential to authority, custom and tradition.
Appreciative, patient, helpful, gentle, moderate, persevering, sincere; being respectful and accepting of others; behaving in a conscientious and sympathetic way.	18. Fe (femininity) To assess the masculinity or femininity of interests. (High scores indicate more feminine interests, low scores more masculine.	Outgoing, hard-headed, ambitious, masculine, robust, active, restless, opportunistic in dealing with others; blunt and direct in thinking and action; impatient with delay, indecision and reflection.

as either verbal or numerical permitted the measurement of two aspects of achievement.

The Hypothesis

The basic hypothesis under consideration in this study is that personality, as assessed with the California Psychological Inventory (CPI), is related to verbal and numerical achievement as assessed from the student's midterm and final examinations in physical science. This basic hypothesis was interpreted in two ways, which are hereafter referred to as hypotheses A and B. These two approaches or interpretations are best illustrated in terms of the following two questions. One: are any of the 18 aspects of personality, as assessed by the CPI, related to either verbal or numerical achievement? Two: are any of the 18 aspects of personality, as assessed with the CPI, related to verbal-numerical discrepant achievement?[1]

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[1] Discrepant achievement is a commonly used term in cases where more than one aspect of aptitude or achievement is being considered.

For purposes of discussion in this study, the term verbal-numerical discrepant achievement will refer to the numerical value of the ratio of numerical achievement to verbal achievement and will be symbolized by N/V where N = numerical achievement and V = verbal achievement.

The significance of this ratio can be illustrated by the following example. Let the N/V values for students A and B be .10 and .45 respectively. These values can be plotted along a continuum on which one extreme is described as low numerical-high verbal

In essence then, Hypothesis A affords a means of characterizing the personality traits of a high achiever when a single aspect of achievement is under consideration while Hypothesis B permits the identification of personality traits which characterize discrepant achievers, viz. individuals who simultaneously perform well in numerical skills and poorly in verbal skills or vice versa.

Since Hypothesis A deals with 18 personality traits and two aspects of achievement it is necessary to test 36 pairs of variables for the existence of significant correlations. In Hypothesis B however, only 18 pairs of variables are involved since the two achievement score values are used to derive a single value; that of the ratio of the two scores. Consequently, the statistical treatment of Hypothesis A assumes the form of 36 sub-hypotheses which are stated in null form below. Similarly, Hypothesis B gives rise to 18 sub-hypotheses and these are listed below under the heading Hypothesis B.

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and the other extreme is described as high numerical-low verbal. Then student A can be described as high verbal-low numerical compared with student B.

There is considerable evidence in the literature to suggest that some students experience great difficulty in mathematics but perform well otherwise, while other students perform well in mathematics and poorly in verbal skills. The question of importance in this study is, can these two kinds of achievers be distinguished from each other on the basis of measurable differences in their personalities?

Hypothesis A

There is no significant correlation between verbal achievement and personality; and there is no significant correlation between numerical achievement and personality.

The test of Hypothesis A consists of the test of each of the following 36 sub-hypotheses stated in the null form, at the .05 level of probability.

1. There is no significant correlation between Do and N
2. " " " " " " Cs " N
3. " " " " " " Sy " N
4. " " " " " " Sp " N
5. " " " " " " Sa " N
6. " " " " " " Wb " N
7. " " " " " " Re " N
8. " " " " " " So " N
9. " " " " " " Sc " N
10. " " " " " " To " N
11. " " " " " " Gi " N
12. " " " " " " Cm " N
13. " " " " " " Ac " N
14. " " " " " " Ai " N
15. " " " " " " Ie " N
16. " " " " " " Py " N
17. " " " " " " Fx " N
18. " " " " " " Fe " N

19. There is no significant correlation between Do and V
20. " " " " " " Cs " V
21. " " " " " " Sy " V
22. " " " " " " Sp " V
23. " " " " " " Sa " V
24. " " " " " " Wb " V
25. " " " " " " Re " V
26. " " " " " " So " V
27. " " " " " " Sc " V
28. " " " " " " To " V
29. " " " " " " Gi " V
30. " " " " " " Cm " V

31. There is no significant correlation between Ac and V
32. " " " " " Ai " V
33. " " " " " Ie " V
34. " " " " " Py " V
35. " " " " " Fx " V
36. " " " " " Fe " V

In the test of Hypothesis A the Pearson product-moment correlation coefficient (r) is computed between each of the 18 personality traits and verbal achievement (V). The resulting 18 values of r are used to test the significance of sub-hypotheses 1-18 above. Similarly, the value of r is computed between each personality trait and numerical achievement (N), and these values are used to test the significance of sub-hypotheses 19-36 above. These 36 correlation coefficients represent the tests of the above mentioned 36 sub-hypotheses and can be presented in the following general form: there is no significant correlation between (X) and (Y), where the variable X represents one of the 18 personality traits and the variable Y represents verbal or numerical achievement. The resulting 2 by 18 matrix of Pearson r's presented in Figure 2 represents the test of Hypothesis A in tabular format. Thus the 36 null hypotheses, which constitute the general statement referred to as Hypothesis A, are represented in the following equivalent, null statement of Hypothesis A: None of the 36 values of r in Figure 2 is significant at the .05 level of probability. The significance or non-significance, at the .05 level, of each r in Figure 2, represents the acceptance or

rejection of the corresponding sub-hypotheses listed on pages 15 and 16. For example, if the value of $r_{N, Sy}$ in Figure 2 is significant at the .05 level, sub-hypothesis number 3 on page 15 would be rejected, and one would be led to conclude that numerical achievement (N) is related to Sociability (Sy).

Figure 2. Pearson product-moment correlation coefficients between personality and achievement for the test of Hypothesis A.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N	$r_{N, Do}$	$r_{N, Cs}$	$r_{N, Sy}$	$r_{N, Sp}$	$r_{N, Sa}$	$r_{N, Wb}$	$r_{N, Re}$	$r_{N, So}$	$r_{N, Sc}$
V	$r_{V, Do}$	$r_{V, Cs}$	$r_{V, Sy}$	$r_{V, Sp}$	$r_{V, Sa}$	$r_{V, Wb}$	$r_{V, Re}$	$r_{V, So}$	$r_{V, Sc}$
	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N	$r_{N, To}$	$r_{N, Gi}$	$r_{N, Cm}$	$r_{N, Ac}$	$r_{N, Ai}$	$r_{N, Ie}$	$r_{N, Py}$	$r_{N, Fx}$	$r_{N, Fe}$
V	$r_{V, To}$	$r_{V, Gi}$	$r_{V, Cm}$	$r_{V, Ac}$	$r_{V, Ai}$	$r_{V, Ie}$	$r_{V, Py}$	$r_{V, Fx}$	$r_{V, Fe}$

Hypothesis B

<u>There is no significant correlation between the ratio of numerical achievement to verbal achievement and personality.</u>

The test of Hypothesis B consists of the test of each of the following 18 sub-hypotheses stated in the null form, at the .05 level of probability.

37. There is no significant correlation between Do and N/V
38. " " " " " " Cs " N/V
39. " " " " " " Sy " N/V
40. " " " " " " Sp " N/V
41. " " " " " " Sa " N/V
42. " " " " " " Wb " N/V
43. " " " " " " Re " N/V
44. " " " " " " So " N/V

45. There is no significant correlation between Sc and N/V
46. " " " " " To " N/V
47. " " " " " Gi " N/V
48. " " " " " Cm " N/V
49. " " " " " Ac " N/V
50. " " " " " Ai " N/V
51. " " " " " Ie " N/V
52. " " " " " Py " N/V
53. " " " " " Fx " N/V
54. " " " " " Fe " N/V

In order to test Hypothesis B, achievement in physical science was defined as the fraction N/V. This representation permits the ranking of subjects along a one-dimensional continuum on which the two extremes are described as high numerical-low verbal, indicated by the large values of N/V, and low numerical-high verbal, corresponding to the small values of N/V. (See footnote page 13 for further details.)

The assertion set forth in Hypothesis B, namely that high numerical-low verbal subjects can be distinguished from low numerical-high verbal subjects on the basis of personality differences, is equivalent to the assertion that one or more of the personality variables will be significantly correlated with the statistic N/V. Consequently, the test of Hypothesis B is similar to that of hypothesis A, in that Pearson r's are used to test the sub-hypotheses; and different in that the two achievement variables, N and V, are combined to form a single variable N/V. Consequently Hypothesis B consists of 18 sub-hypotheses. Figure 3 represents the test of Hypothesis B

in tabular form. Stated in its null form Hypothesis B is: none of the 18 values of r in Figure 3 is significant at the .05 level of probability.

Figure 3. Pearson product-moment correlation coefficients between personality and achievement for the test of Hypothesis B.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N/V	$r_{N/V,Do}$	$r_{N/V,Cs}$	$r_{N/V,Sy}$	$r_{N/V,Sp}$	$r_{N/V,Sa}$	$r_{N/V,Wb}$	$r_{N/V,Re}$	$r_{N/V,So}$	$r_{N/V,Sc}$
	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N/V	$r_{N/V,To}$	$r_{N/V,Gi}$	$r_{N/V,Cm}$	$r_{N/V,Ac}$	$r_{N/V,Ai}$	$r_{N/V,Ie}$	$r_{N/V,Py}$	$r_{N/V,Fx}$	$r_{N/V,Fe}$

Since the population under consideration in this study was divided into four groups, both hypotheses A and B, were tested four times. (See section on research design in Chapter III for details.)

Assumptions

The following statements comprise the premises which obtain here:

1. The measuring devices used in this study are valid and reliable measures of their respective variables.

2. The responses of the subjects who were retained for data treatment, to the above mentioned devices were made as sincerely and honestly as possible.

Limitations

This study was limited to those students enrolled in General Science 104 (G. S. -104), at Oregon State University during the fall term of 1966.

This course is the first term of a three term sequence in introductory physical science, designed to meet the needs of the non-science major. The enrollment in GS-104 typically consists of students from many of the departments on campus and from all grade levels. A tally of 264 students made one year prior to this study, showed 108 freshmen, 71 sophomores, 50 juniors, 33 seniors, and 2 graduates. These students listed 29 departments as majors. Almost 68 percent of them were from the following three schools: School of Humanities and Social Science, School of Business and Technology, and School of Education.

II. REVIEW OF THE LITERATURE

General

The successful prediction of academic performance has long been a problem of great interest to educators, psychologists, guidance counselors, and others. The past two decades have seen a considerable increase in research efforts devoted to this problem. Lavin (1965, p. 11) suggests what appear to be the three most common reasons given for this increased interest.

> One reason for this is the much publicized growth in the student population. On the college level the increase has outstripped the expansion of facilities, consequently heightening the competition for admission, especially at the better universities and colleges. For college admissions officers the selection of students is more difficult than ever before because the increase in the sheer number of applicants is paralleled by growth in the number of highly qualified candidates. Thus, the responsibility of colleges to be as certain as possible that the students they select will do better than those they exclude is becoming increasingly difficult to fulfill.
>
> A second source of interest in the prediction of academic performance is the growth of programs designed to identify and support the training of students with outstanding talents. Such programs (for example, that of the National Merit Scholarship Corporation) reflect the exigencies of the post-Sputnik Cold War competition and the national need to find those persons able to absorb and use high-level scientific and technical training. If students selected for support by these programs do not perform according to expectations, money is wasted and others who might be better risks are lost to the nation's pool of trained manpower.
>
> A third reason for increased interest in predicting academic performance is the development within the

> social sciences of the serious, concerted study of education. While long an active concern of psychology, education has not until recently been of equal interest to sociology. Recent developments suggest that education is being given increasing attention by sociology. This is probably because the classroom furnishes a testing ground for basic theory and because sociology is now in a position to provide some answers for the practical problems of education.

Early Work

Devices utilized for the prediction of academic achievement in early work were restricted for the most part to measures of aptitude and general intelligence. However, it has long been recognized that, at best, such devices are only able to account for slightly less than half of the variation in academic performance (Lavin, 1965, p. 64). Consequently, in their efforts to seek means for more valid prediction of academic achievement, investigators have broadened the scope of their efforts to include measures of the so-called non-intellectual factors. In this regard, many investigators have focused their work on the relationship between academic achievement and various facets of personality.

For the purposes of this review, all of the research summarized here can be conveniently divided into two general classes referred to hereafter as personality-achievement and personality-differential achievement.

In the research which falls into the former classification, the

achievement criterion is defined in terms of overall academic success and the most common measure of such success is grade point average (GPA). The usual objective of this kind of research is to isolate measurable aspects of personality which allow one to discriminate between several degrees of academic achievement such as underachiever, average achiever, and overachiever.

In research of the latter kind, the objective consists of an attempt to isolate those personality traits requisite for success in a given academic discipline, or those personality traits which seem related to certain intellectual skills. For example, one may ask, how does the personality of a successful engineering major differ from that of a successful history major; or what personality differences are measurable between high and low mathematics achievers. The present study is of the personality-differential achievement type, since the objective here is to search for relationships between personality and two kinds of achievement.

Personality-Achievement Investigations

Early work was confined essentially to studies of the former kind and these studies produced no significant results. Stagner (1933) in reviewing a number of studies prior to 1933 notes that no significant relationships between personality and achievement could be found. Somewhat later, Gough (1949, p. 66) suggests that the

dearth of useful results from studies prior to 1933 might be attributed to the inappropriate use of the personality tests then in existence. He states:

> One reason for this [lack of success] may be that they have tended to use scale scores from instruments which were devised for use in other prediction problems, often clinical, and with no intended relationship to the variables relevant to academic achievement. For example, there is no reason to expect that a scale designed to reveal neuroticism would discriminate either under or over-achievers as a group.

However, at the time Gough made this remark, work was being carried on by a number of investigators (Altus, 1948; Barow, 1945; Brown, 1947; Gough, 1949, and others) toward the development of more appropriate personality instruments. The result was a great proliferation of empirically keyed personality inventories designed for use with normal individuals. Some of the well-known inventories of this type are the California Psychological Inventory, Edwards Personal Preference Schedule, Gordon Personal Profile, Guilford-Zimmerman Temperament Survey, and the Sixteen Personality Factor Questionnaire.

The advent of a variety of personality inventories designed for use with normal individuals gave great impetus to the research efforts focused upon the relationship between academic achievement and personality. Presently, the widely diversified nature of such research tends to give rise to what appears to be certain

inconsistencies and contradictions. However, as indicated in Chapter I, most authorities agree that further research promises to provide an increased understanding of the relationship between personality and achievement.

Taylor (1964) in reviewing the literature on personality and achievement attempts to diminish some of the apparent contradictions by hypothesizing the following generalized personality traits: academic anxiety, self value, authority relations, interpersonal relations, independence-dependence conflict, activity patterns, and goal orientation. Taylor's summary of his review, Figure 4, indicates the direction taken by each of these seven generalized traits in the low and high achiever. However, what is not evident in Figure 4 are the many conflicting results which Taylor encountered in his detailed consideration of the literature. For example, in his findings on authority relations, he states (Taylor, 1964, p. 78):

> Several investigations indicated that the overachiever has a good relationship with parents (Gowen, 1957; Gough, 1953; Horall, 1957; Kurtz and Swenson, 1951). The parents are interested and supportive in regard to their children's academic success and the children in turn respect their parents and attempt to please them by doing well academically. . .
>
> Several other investigators indicate that there may be a negative relation between overachievers and their parents (Drews and Teahan, 1957; Haggard, 1957; Hoffman, Rosen and Lippit, 1960; Horrall, 1957) the theoretical assumption being that a child unable to obtain love, warmth and understanding at home will compensate for these needs by seeking, in their place, a teacher's approval of his academic achievements.

Figure 4. Summary of Taylor's Generalized Personality Traits and their directions for high and low academic achievement.

Direction of low achiever	Trait	Direction of high achiever
Free floating anxiety	Academic anxiety	Directed anxiety
Negative self-value	Self-value	Positive self-value
Hostility towards authority	Authority relations	Acceptance of authority
Negative interpersonal relations	Interpersonal relations	Positive interpersonal relations
High independence-dependence conflict	Independence-dependence conflict	Low independence-dependence conflict
Socially oriented	Activity patterns	Academically oriented
Unrealistic goal orientation	Goal orientation	Realistic goal orientation

Similar conflicting results are reported for the traits of self-value, interpersonal relations, and independence-dependence conflict.

A shortcoming in the kind of approach represented in Taylor's work (i.e., to seek well-defined personality-achievement relationships from a wide range of literature), is that many studies are not truly comparable due to the variety found among the measuring instruments, the experimental design, and the populations. An obvious partial solution to this kind of difficulty is to focus upon the findings of a single personality inventory. In this regard, the studies which have employed the California Psychological Inventory (CPI), one of the most widely used instruments of its kind, are reviewed in the following section.

The California Psychological Inventory and Achievement

Holland (1959) administered the CPI to a sample of 743 Merit Scholars and 578 Certificate of Merit Winners in an attempt to predict college achievement. Among the females, six of the CPI scales were significantly correlated with college grades at the .01 level, while among the males, eight scales were so correlated. In the case of the males the eight scales were: Capacity for Status, Sociability, Social Presence, Self-Acceptance, Responsibility, Socialization, Self-Control, and Femininity. In the case of the females five of the scales were the same as for males, they were: Social-Presence,

Responsibility, Socialization, Self-Control, and Femininity. Achievement-via-Conformance was significant in the case of the females but not in the case of the males.

Pierce (1961) employed the CPI in an extensive study of 54 tenth grade and 50 twelfth grade boys of superior ability in a mid-western public high school. Among the tenth graders, nine CPI scales significantly differentiated between underachievers and over-achievers at the .05 level or better (see Figure 5) while among the twelfth graders eight scales did so. The nine scales which differentiated achievement among tenth graders were: Responsibility, Socialization, Self-control, Tolerance, Achievement-via-Conformance, Achievement-via-Independence, Intellectual Efficiency, Psychological mindedness, and Femininity. The eight scales which differentiated achievement among the twelfth graders were Capacity for Status, Sociability, Responsibility, Tolerance, Communality, Achievement-via-Conformance, Achievement-via-Independence, and Intellectual Efficiency. The results from the two grade levels contain five CPI scales in common.

In a study of 60 pairs of "intellectually superior" ninth and tenth grade boys by Young (1962), 11 CPI scales (level of significance not indicated), differentiated overachievers from underachievers. These 11 scales were: Dominance, Sense of well-being, Responsibility, Socialization, Tolerance, Communality, Self-Control,

Achievement-via-Conformance, Achievement-via-Independence, Intellectual Efficiency, and Femininity.

Similar investigations upon samples of "average" students seem to be somewhat less productive of significant findings. For example, Hunt (1961) employed the CPI in an investigation of those seniors at Ball State Teachers' College who had scored between the thirty-fourth and sixty-sixth percentile on the American Council on Education Psychological Examination (ACE). The subjects were classified as under or overachievers on the basis of their grade point average. The mean ACE scores for the over and under achieving groups were not significantly different, therefore the two groups were of equal ability as measured by the ACE.

Hunt found that among the males, at the .05 level, only one CPI scale, Intellectual Efficiency, differentiated overachievers from underachievers. Among the females, six CPI scales differentiated between overachievers at the .05 level or better. They were: Dominance, Tolerance, Achievement-via-Conformance, Responsibility, Good Impression and Achievement-via-Independence.

Winkelman (1962) in a study of 60 male college sophomores found that none of the 18 CPI scales differentiated overachievers from underachievers.

Lanier (1962) in studying freshmen at Purdue University found four CPI scales which distinguished between male overachievers

and underachievers and two CPI scales which distinguished between female overachievers and underachievers.

Flaherty and Reutzel (1965) in a study of freshmen at Mount Mercy College (a small liberal arts college for women) found 11 of the CPI scales differentiated high achievers from low achievers. The scales which were significant at the .05 level or better were Dominance, Capacity for Status, Sociability, Self Acceptance, Responsibility, Tolerance, Achievement-via-Conformance, Achievement-via-Independence, Intellectual Efficiency, Flexibility, and Femininity.

In limiting the discussion to the results of one personality instrument, a noticeable increase in consistency becomes apparent. With the exception of Holland's results, an inspection of Figures 5 and 6 indicates that several of the CPI scales are repeatedly significant in differentiating academic achievement as measured by overall grade point average.

Although some improvement in consistency of results has been realized by restriction of the discussion to the results obtained with one personality instrument, a serious limitation is imposed by the commonly used achievement criterion of grade point average.

The use of grade point average (GPA) as the sole criterion for achievement, tends to be invalid to the extent that it varies as a function of institution, instructor, and academic discipline. For

Figure 5. CPI scales found to significantly differentiate underachievers from overachievers as reported in the literature.

	Males																	
	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
Holland (1959) N = 476		.01	.01	.01	.01	.	.01	.01	.01								.05	.01
Pierce (1961) (grade 12) N = 50		.01	.01				.01			.01		.05	.05	.01	.05			
Pierce (1961) (grade 10) N = 54							.01	.01	.05	.05			.05	.05	.05	.05		.05
Young (1962) N = 120	X					X	X	X	X	X		X	X	X	X			X
Hunt (1961) N = 90															.05			
Winkelman (1962) N = 60																		
Lanier (1962	X							X	X					X				

.01 = significant at .01 level
.05 = significant at .05 level
X = significant, level not given

Figure 6. CPI scales found to significantly differentiate underachievers from overachievers as reported in the literature.

	Females																	
	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
Holland (1959) N = 185				.01	.05		.01	.01	.01				.01	.05				.01
Hunt (1961) N = 72	.01						.05			.01	.05		.01	.05				
Flaherty and Reutzel N = 149	.01	.05	.05		.01		.01			.05			.01	.05	.01		.01	.05
Lanier (1962)											X		X					

.01 = significant at .01 level
.05 = significant at .05 level
X = significant, level not given

example, closer examination of Holland's work (1959) indicates that the CPI scales which were significantly correlated with GPA were not the same from one institution to the next. The significant scales (at the .01 level) at California Institute of Technology for boys were Socialization and Achievement-via-Conformance: while for the boys at Harvard, they were Capacity for Status, Social Presence, Self Acceptance, Responsibility, Socialization, Self-control, and Femininity: and for boys at M. I. T. they were Good Impression and Achievement-via-Conformance. Evidently in Holland's sample, GPA varies from one institution to the next or the personality traits necessary for success at each institution vary with the institution or a combination of both. In this regard Lavin (1965, p. 19) notes the following:

> Relatively little attention is given to the possibility that low correlations might also be due to uncontrolled sources of variation in grades themselves. Although this problem has been discussed, it has not been investigated systematically. When one examines this question, it becomes clear that there are so many sources of uncontrolled variation that substantial increases in predictability may not be forth coming until they are controlled.
>
> These sources of variation fall into two categories. First, not all students take the same courses. They major in different curricular areas (particularly on the college level), and some types of majors may be more difficult than others.
>
> Second, teachers use different criteria in assigning grades.

The limitations imposed through the use of GPA as the achievement criterion are largely avoided in the following studies, classed

under the heading of Personality-Differential Achievement.

Personality and Differential Achievement

Two kinds of studies are included in this classification. There are those investigations which attempt to identify personality characteristics associated with students majoring in a particular discipline. Also included, are those investigations in which one attempts to identify personality characteristics associated with achievement, in which achievement is defined in terms of performance on a standardized test.

Maxwell (1960) studied the personalities of the male students enrolled in various college curricula at the University of Maryland using the CPI. In the study, three of the CPI scales differentiated between students in different colleges thus suggesting that there are measurable personality differences between students of various college curricula.

Weiss (1962, p. 60) has observed measurable differences between science and non-science majors employing the "Is of Identity Test". Conclusions were:

> The analysis showed that differences in test scores could not reasonably be associated with sex differences, age differences of college grade levels. This further confirmed results of earlier studies. There were significant differences between science and non-science majors at the .05 probability level, however, when mathematics majors were analyzed separately no

significant differences were found between them and non-science majors.

Goldschmid (1965, p. 4074) in a rather complex study to determine the personality differences between students who are science majors and those who are humanities majors at the University of California at Berkeley, concludes with the following characteristics:

> Science majors: They prefer overt action and tend to evaluate an idea on the basis of its practical and immediate applications. They are relatively free from self-doubt and worries, but tend toward strict control of impulse. Their range of interest is rather restricted. In social situations they are reserved, retiring and introverted. They prefer logical, precise analysis, and value form and structure. They are also characterized by impersonal and critical habits of thinking.
>
> Humanities majors: They are self-centered and given to complaining about their physical and psychological status. They are emotionally expressive and anxiety-prone. Their interests are varied and include literature, philosophy, art and religion. They are responsive to social and political affairs, seek social contacts and gain satisfaction from them. Their preferred cognitive mode is intuitive, personal and subjective. They like innovation and ambiguity.

Other works lend support to the hypothesis that success in science might well require certain social-psychological prerequisites. Anne Roe (1951, p. 60), in a biographical study of eminent biologists, concludes:

> Social and personal relations tend to be at least superficially smooth, but often not warm. . . They are not very "outgoing" persons in a social sense and would not rate very high in 'masculinity' . . . A general picture of shyness, lateness in developing interest in or in being able to express interest in girls, and present general disinterest in most social contacts is

> characteristic of all but one or two of this group. (The group consisted of 20 biologists).

And Roe (1953, p. 52) further concludes that:

> Clearly a certain degree of intelligence is a necessary condition for a career in research science, but it is not a sufficient one.

Cline, Richards, and Abe (1964, p. 398) were led to similar conclusions in their biographical study of science achievement of high school students. They summarize their findings as:

> . . . excellence in science studies is related to more than just intelligence. . . The family background (e.g. educational level of parents, occupation of father, but not such things as strictness in child rearing) and social milieu in which the child is raised do have a tremendous impact upon his attitudes toward education, his motivation in science studies, and to a considerable extent, his selection of a science area as a career.

A search of the literature relating personality and mathematical achievement reveals a paucity of findings. However, the following several studies seem germane to this investigation.

Schulman (1964, p. 2355) employed the Roschach test of personality in the investigation of gifted male students from "two general-academic public high schools in the New York City area." He concludes that:

> Non-intellectual personality factors do affect quantitative ability. Specifically, these gifted adolescents with lower anxiety, higher self-esteem, lower dependence and higher assertiveness, tend to be those with higher quantitative ability.

Keimowitz and Ansbacher (1960, p. 87) employed the CPI in their study of 56 eighth grade public school boys. They note that the overachievers scored significantly differently from the low achievers on 12 of the CPI scales, and that "the overachievers emerged with higher scores, i.e., more favorable personality characteristics than the underachievers. . ." The significant scales were Capacity for Status, Self-control, Psychological Mindedness, Tolerance, Social Presence, Achievement-via-Conformance, Achievement-via-Independence, Intellectual Efficiency, Sociability, Socialization, Responsibility, and Good Impression.

A number of investigators have concerned themselves with the investigation of "intraindividual verbal-numerical discrepancies" and personality. (I.e., they have sought a relationship between a subject's personality and the extent to which there exists a discrepancy between his verbal ability and numerical ability scores.) The work of Munroe (1946), Pemberton (1951), and Dana et al. (1959), seems to indicate that subjects possessing high verbal and low mathematical abilities tend to be more subjectively oriented, make greater use of repression and projection and tend to have more distorted thinking than those subjects who were characterized as high quantitative and low verbal.

Summary of Review of Literature

A great deal of research has been undertaken for the purpose of seeking increased understanding of the relationship between personality and academic achievement. Much of the motivation for this research is derived from attempts to establish early identification of scientifically talented youngsters. Further impetus is derived from attempts to provide for more effective counseling techniques through the use of improved prediction of student academic performance in high school and college.

Early work was confined to the use of clinical instruments applied to non-clinical situations and as a result produced few significant findings. Later development of personality instruments for use with normal populations gave rise to greatly expanded research efforts.

Many such studies employ grade point average as the sole achievement criterion and among the results of these studies there appears to be considerable disagreement. However, a frequently occurring finding in this type of research is that achievement appears to be positively correlated with socially acceptable personality traits.

In attempting to resolve some of the conflicting results, researchers have invoked several types of restriction. For example the studies of Maxwell (1960), Weiss (1962), and Goldschmid (1965),

are restricted to students within a single academic discipline. Other restrictions take the form of limitation of sample population to one of homogeneous ability, use of standardized aptitude tests in lieu of grade point average, limitation of academic achievement to a single aspect of achievement, and the use of a single personality assessment instrument.

Many of these restricted studies lend considerable support to the thesis that personality traits tend to be significantly correlated with certain kinds of intellectual achievement. For example, the work of Maxwell (1960), Weiss (1962), and Goldschmid (1965) represents strong support of the hypothesis that persons of different academic majors can be distinguished on the basis of measurable differences in their personalities. Implied in such work is the notion that success in a particular academic discipline is partly dependent on certain pre-requisite personality traits. To the extent that success in the study of a given discipline is dependent upon certain intellectual skills, it would appear that personality is related to intellectual achievement.

Additional support of the notion that personality is related to intellectual accomplishment seems clearly evident from the work dealing with verbal-numerical discrepancies.

III. DESIGN OF THE STUDY

Research Design

The statistical design employed in this study consisted of a zero order correlational analysis involving 18 personality variables and two achievement variables. Since the general hypothesis that personality is related to verbal and numerical achievement in science was given two interpretations, namely hypothesis A and hypothesis B, the correlational analyses assumed two slightly different formats as indicated in Figures 2 and 3 respectively.

The population under consideration in this study was classified into four groups each of which was subjected to the same statistical analysis. The four groups resulted from classification of the population according to sex and according to examination author. The classification according to examination author was necessary because the two sections of GS-104 received both instruction and testing from different individuals. Consequently the four groups into which the population was divided are designated as follows: OSU section A males, OSU section B males, OSU section A females, OSU section B females.

Since both hypotheses A and B were tested in each of the four population subdivisions, the major findings of this study

consist of eight sets of correlation coefficients. For example, the test of hypothesis A on any sample involves the computation of 36 Pearson product-moment correlation coefficients corresponding to the 36 null sub-hypotheses listed on page 15. Consequently, the four tests of hypothesis A resulted in four sets of such coefficients; each set containing 36 values of r. Similarly, each test of hypothesis B in the four population groups gives rise to a set of 18 values of r.

In addition to the eight sets of data comprising the major portion of the study, a supplementary analysis was conducted in an attempt to answer the following question: how does the verbal-numerical classification criterion employed in this study compare with that used by the College Entrance Examination Board? (See top of page 46 for further details.)

Statistical Procedures

All test scoring and computation was accomplished through the use of the Utah State University Statistical Laboratory and the Utah State University Computer Facility. All correlation coefficients used in this study are of the Pearson product-moment type.

Population

The population was limited to students at Oregon State University who were enrolled in General Science 104 during the fall term

of 1966.

Since this course is taught at different hours by different instructors the population was classified according to lecture section as OSU section A and OSU section B. In section A there were 35 males and 98 females retained in the study while in section B there were 23 males and 57 females.

Measuring Instruments

The California Psychological Inventory, used to measure the personality traits of the subjects, was chosen for two reasons: it has received much more favorable reviews in the Mental Measurements Yearbook (Buros, 1966) than any other instrument of its kind; and the wide application which it has enjoyed in personality-achievement research provides a background of somewhat comparable results for reference.

The inventory consists of 480 true-false items, somewhat randomly distributed over the 18 personality scales, and requires about 45 to 60 minutes to complete. It has been used successfully in research on subjects from age 12 to age 70. Gough (1964, p. 5) states that the purpose of the CPI is as follows:

> The California Psychological Inventory was created in the hope of attaining two goals of personality assessment. The first goal, largely theoretical in nature, has been used to develop descriptive concepts which possess broad personal and social relevance. Many of the

> standard personality tests and assessment devices available previously have been designed for use in special settings, such as the psychiatric clinic, or have been constructed to deal with a particular problem, such as vocational choice. The present endeavor has been concerned with characteristics of personality which have a wide and pervasive applicability to human behavior, and which in addition are related to the favorable and positive aspects of personality rather than to the morbid and pathological.

Personality Data Collection

At Oregon State University (OSU), students who are majoring in fields other than the physical sciences may meet the science graduation requirement by taking one year of physical science. This requirement may be satisfied by electing a year sequence in chemistry or physics, but most students, lacking adequate background, choose instead the year sequence in physical science numbered General Science 104, 105, 106. The enrollment in this course is handled by two lecture instructors and three laboratory instructors. Students enrolled in this course attend three one-hour lectures per week and one two-hour laboratory session per week. During the fall term of 1966, the course was taught by two lecturers and three laboratory instructors and about 300 students were enrolled. The California Psychological Inventory was administered during the second hour of the first fall term laboratory session to every student in attendance, by the laboratory instructor normally scheduled

for that session. The answer sheets were then mailed to the author and scored on the IBM optical scanning equipment at the Utah State University Computer Facility. Those few students who could not complete the inventory during the alloted time were eliminated from the study.

Achievement Data Collection

All questions on the midterm and final examinations for both sections of General Science 104 at Oregon State University were classified as either verbal or numerical in accordance with the criterion used for similar classification by the College Entrance Examination Board. A student's verbal achievement in physical science is represented by the total number of verbal questions answered correctly during the term. Similarly, a student's numerical achievement in physical science is represented by the total number of numerical questions answered correctly during the term.

Copies of the midterm and final examinations for General Science 104 were mailed together with the student's answer sheets to the author during the fall term of 1966. The answer sheets, having already been scored at Oregon State University, contained scores representing the total number of items answered correctly by the student. A "numerical key" was constructed by the author and the answer sheets were manually rescored, consequently each

student's answer sheet contained two scores, namely the total number of items answered correctly and the total number of numerical items answered correctly. The difference between these two scores is taken to be the total number of verbal items answered correctly. This procedure was employed for both of the one hour examinations and the final examination in General Science 104.

Treatment of Data

The computer program employed in this study is not capable of executing the appropriate mathematical operations in the case of missing observations. Consequently a number of subjects were eliminated from the study because certain data were missing.

Most eliminations stemmed from two causes. Either the student had not completed the personality inventory or he failed to take one or more of the examinations in the course.

Since there were two scores for each examination, a total score and a numerical score, and since the students in General Science 104 were given two one-hour examinations and a final examination, a total of six achievement scores resulted. These six achievement scores and the 18 CPI scores constituted the complete data for each subject. Subjects for which all 24 scores were not available were eliminated from the study.

A Comparison of the Verbal-Numerical Classification Criterion

In this study, physical science examination questions were classified as 'numerical' whenever the use of mathematics was a necessary requisite in selecting the correct response to an item. Items which did not clearly meet this criterion were classed as verbal. According to the Educational Testing Service, the Scholastic Aptitude Test (SAT) measures verbal and quantitative (referred to as mathematical in this study) abilities. ETS defines verbal ability as "the student's understanding of words and his ability to comprehend written materials" and quantitative ability as "the student's ability to perform fundamental operations with numbers and to use reasoning to solve number problems". (Educational Testing Service, 1965, p. 3).

In order to determine the degree of correspondence between this criterion and that employed by the College Entrance Examination Board Test (the Scholastic Aptitude Test), the verbal and numerical achievement scores in physical science were correlated with the SAT verbal and mathematical scores, for a portion of each of the four groups at Oregon State University in accordance with Figure 7. Numerical achievement in physical science was correlated with both mathematical and verbal achievement on the SAT. Verbal

achievement in physical science was similarly treated. If the criterion used in this study is identical to that of the SAT and if mathematical and verbal abilities are independent, $r_{n, M}$ and $r_{v, V}$ would have values of one while $r_{v, M}$ and $r_{n, V}$ would have values of zero. The deviation from this ideal is indicative of the dissimilarities in the two criteria.

Figure 7. Correlations for comparison of the verbal-numerical classification criterion of this study and that of the Scholastic Aptitude Test.

	SAT M	SAT V
n	$r_{n, M}$	$r_{n, V}$
v	$r_{v, M}$	$r_{v, V}$

n = numerical achievement in this study

v = verbal achievement in this study

M = SAT math score

V = SAT verbal score

IV. PRESENTATION AND INTERPRETATION OF DATA

General

As mentioned previously, the test of the general hypothesis, that personality is related to verbal and numerical achievement in physical science, has assumed the form of two interpretations in this study. These two interpretations referred to as hypotheses A and B are respectively represented by the 36 sub-hypotheses listed on page 15 and the 18 sub-hypotheses listed on page 17. The equivalent tabular representations of these two sets of sub-hypotheses are presented in Figures 2 and 3. Since both sets of sub-hypotheses, i.e., hypothesis A and hypothesis B, were tested in each of the four population sub-divisions, the major findings of this study are represented in the form of the eight tables, Figures 8 to 11 and 14 to 17. Four of these tables, Figures 8 to 11, contain 36 values of the Pearson product-moment correlation coefficient. These four sets of 36 values, correspond to a test of each of the 36 sub-hypotheses associated with hypothesis A, in each of the four population sub-divisions. In a similar manner the four tables, Figures 14 to 17, each contain 18 values of the Pearson r, resulting from the test of the 18 sub-hypotheses associated with hypothesis B in the four population sub-divisions.

Hypothesis A and the Two Groups of Males

The correlations between personality and verbal-numerical achievement in section A and B males at Oregon State University are shown in Figures 8 and 9.

Among the section A males three personality scales, Dominance, Sociability, and Communality correlated significantly at the .05 level with achievement. Dominance and Sociability were related to verbal achievement and Communality was related to numerical achievement. Among the section B males Self-Control and Achievement-via-Conformance were significantly related to verbal achievement, while none of the personality traits were significantly related to numerical achievement.

Figure 8. Hypothesis A: Zero order correlations for OSU Section A Males.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N	.181	.142	.168	-.011	.274	-.177	-.015	-.246	-.191
V	.348*	.197	.410*	-.020	.323	0.182	-.110	-.112	-.153

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N	-.062	-.041	-.375*	-.118	-.080	-.228	.247	.044	-.265
V	-.163	-.052	-.174	-.065	-.067	.006	.103	-.101	.156

N = 35

$r_{.05} = .333$

$r_{.01} = .429$

*significant at .05 level

Figure 9. Hypothesis A: Zero order correlations for OSU Section B Males.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N	.256	.121	.216	-.125	-.018	.128	.193	.324	-.124
V	-.165	.019	-.039	.106	-.230	.149	.312	.134	.466*

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N	.246	-.260	-.018	-.140	.123	.381	.019	-.041	-.172
V	.348	.319	.363	.451*	.212	.129	-.129	.226	.287

N = 23

$r_{.05} = .413$

$r_{.01} = .525$

*significant at .05 level

The small number of rejections for hypothesis A in the two sections of males suggests the acceptance of the notion that verbal and numerical achievement in physical science are not related to personality as assessed with the CPI.

Hypothesis A and the Two Groups of Females

The values of the correlation coefficients between personality and verbal and numerical achievement in section A and B females are shown in Figures 10 and 11.

Among the section A females there were nine significant relationships involving seven personality traits. The traits were Sociability, Self Acceptance, Sense of Well-Being, Tolerance,

Good Impression, Achievement-via-Independence, and Flexibility. Four of these, Sense of Well-Being, Tolerance, Good Impression, and Achievement-via-Independence, were significantly correlated with numerical achievement, while five of them, Sociability, Self Acceptance, Sense of Well-Being, Achievement-via-Independence, abd Flexibility were significantly correlated with verbal achievement.

The results among the Section B females were markedly different from those in Section A. In Section B only two personality traits, Dominance and Flexibility, correlated significantly with achievement. Dominance was related to verbal achievement while Flexibility was related to numerical achievement.

Figure 10. Hypothesis A: Zero order correlations for OSU Section A Females.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N	-.085	-.179	-.077	-.049	.028	-.203*	-.096	-.043	-.180
V	-.155	.044	-.240*	-.032	-.216*	.201*	.027	.019	.164

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N	-.235*	-.222*	-.192	-.177	-.199*	-.130	-.100	-.004	.088
V	.167	.156	.062	-.027	.243*	-.177	.057	.202*	-.049

N = 98

$r_{.05} = .198$

$r_{.01} = .259$

*significant at .05 level

Figure 11. Hypothesis A: Zero order correlations for OSU Section B Females.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N	.250	.031	.202	-.061	.194	-.184	.044	.123	-.202
V	.262*	.193	.180	.109	.199	.109	.207	-.026	-.010
	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N	-.150	-.143	.001	.122	-.260	-.186	-.135	-.311*	-.026
V	.081	.107	-.148	.124	.187	.116	-.109	.024	-.062

N = 57

$r_{.05} = .261$

$r_{.01} = .338$

*significant at .05 level

The findings for the section A females suggest very strongly that verbal and numerical achievement in physical science are related to personality, while the findings for the section B females tend to refute this notion.

Acceptance or Rejection of the Hypotheses

In this study the word "hypothesis" refers to a collection of individual, statistically testable statements termed sub-hypotheses. Consequently the meaning of the phrase "acceptance or rejection of a hypothesis" as used in this study needs to be further clarified.

Consider, for example, the test of hypothesis A among the section A females. In this test, the value of each of the 36

correlation coefficients is computed and each of the 36 sub-hypotheses, which constitute hypothesis A, is either accepted or rejected accordingly, at the .05 level. In this test of hypothesis A, nine significant correlations were found; five between personality traits and verbal achievement and four between personality traits and numerical achievement. Then nine of the 36 sub-hypotheses would be rejected, since all statements of sub-hypotheses are in the null form. In this case, hypothesis A would be rejected and the conclusion reached would be that personality is significantly correlated with achievement. Rejection of hypothesis A occurred in this example because a "considerable" number of the sub-hypotheses were rejected. However, since the sub-hypotheses are all tested at the .05 level, one would expect to find five percent of them to be significant due to chance alone. Therefore, if personality were independent of achievement one would expect to reject at least five percent of the 36 sub-hypotheses or approximately two of them. Consequently, in the testing of hypothesis A, the number of rejections in the sub-hypotheses exceeding two is indicative of the extent to which one believes that achievement is related to personality.

Since a test of hypothesis B involves half as many sub-hypotheses, one would expect to find approximately one rejection due to chance. Therefore, at the .05 level, in any test of hypothesis A, one would expect to find at least two significant relationships among

the sub-hypotheses and similarly in every test of hypothesis B at least one of the sub-hypotheses would be significant. Consequently, those instances in which the number of rejections exceeds these minimums, are interpreted as evidence in support of the general notion that academic achievement is related to personality.

A Discussion of Findings for Hypothesis A

Figures 12 and 13 represent a summary of the personality-achievement findings in both sections. The symbols V and N indicate significant correlations with verbal and numerical achievement respectively. The sign preceding the symbol represents the direction of the correlation. An examination of Figures 12 and 13 reveals several interesting features.

1. The total number of significant relationships is approximately two times that expected from chance alone. Figure 13 shows that in the combined results, a total of 16 correlations, significant at the .05 level, occur among the possible 144 values of r. If one assumes, as previously mentioned, that five percent of the 144 correlations will be significant due to chance, then one can attribute about seven of the significant relationships in Figure 13 to chance alone. Hence the number of significant relationships in the four tests of hypothesis A is approximately double that expected from chance.

Figure 12. A summary of findings for Hypothesis A by section and sex

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
Males, Section A	+V		+V									-N						
Males, Section B									+V				+V					
Females, Section A			-V		-V	-N +V				-N	-N			-N +V			+V	
Females, Section B	+V																-N	

Figure 13. Summary of total findings by sex for Hypothesis A

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
Total Males	+V		+V						+V			-N	+V					
Total Females	+V		-V		-V	+V -N				-N	-N			+V -N			+V -N	

V = correlation with Verbal Achievement is significant at the .05 level

N = correlation with Numerical Achievement is significant at the .05 level.

sign is sign of correlation coefficient

Therefore the consideration of the findings obtained from combining the results of all four population sub-divisions, leads to the rejection of Hypothesis A and the conclusion that personality is related to verbal and numerical achievement in physical science. However, a consideration of Hypothesis A within each of the four sub-divisions results in a slightly modified conclusion. Consider, for example, the test of Hypothesis A among the Section A males as summarized in Figure 12. This test involved the computation of 36 values of r, and one would expect five percent of 36, or about two, of these values of r to be significant due to chance alone. As is indicated in Figure 12 there were three significant values of r among the section A males. Thus the findings among the section A males are consistent with the overall findings of this study but are less strongly suggestive of the notion that personality is related to achievement than those of all four groups considered as a whole. Similarly, from Figure 12 it appears that personality and achievement among the section B males were independent, because the number of significant findings was equal to that expected from chance alone. However, among the section A females, Figure 12 reveals that personality and achievement are very highly interrelated, while among the section B females the degree of interrelationship between these two factors is the same as it is among the section A males.

Thus, the overall findings presented in Figure 13 strongly support the general notion that personality and academic achievement are related, while the variation in these findings among the four subgroups, as indicated in Figure 12, suggests the existence of additional factors. One factor which seems to account for a portion of this variation is that of sex and this is discussed below.

2. As is evident from Figure 13, the number of significant relationships among the females is approximately twice as great as it is among the males. There were a total of five significant correlations for the males and 11 for the females. These findings are consistent with those of several investigators in that significant correlations between personality and achievement tend to occur more frequently among female subjects than among male subjects. For example, Hunt (1961) found six CPI scales were significantly related to achievement among female subjects while only one was significantly related to achievement among male subjects. Gough and Fink (1964) note that 14 CPI scales were significantly related to achievement among the females while only 11 were so related among the males. Aiken and Dreger (1961) note the same effect and Aiken (1963) limited a study to females because of this effect. Furthermore, Lavin (1965, p. 56) in discussing the prediction of academic achievement based upon the findings of many studies and the use of numerous assessment instruments has noted that: "With

regard to sex differences, correlations tend to be higher for females than for males in the differential prediction studies which control on this factor."

Personality and Discrepant Achievement

Hypothesis B states, in essence, that subjects who tend to be high in numerical and low in verbal achievement will have personalities measurably different than those subjects who tend to be low in numerical achievement and high in verbal achievement. To test this assertion the correlation between the ratio N/V and each of the CPI trait scores was computed for the subjects in each of the four groups.

Hypothesis B and the Two Groups of Males

Among the section A males, Figure 14 indicates two significant values of r. Both Responsibility and Tolerance correlate positively with N/V. Among the section B males the only significant value of r was between Tolerance and N/V. As previously mentioned one would expect to find on the basis of chance alone, at least one significant relationship among 18 possibilities. The findings presented here in Figures 14 and 15 indicate the acceptance of Hypothesis B for the two sections of males.

Figure 14. Hypothesis B: Zero order correlations for Section A Males.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N/V	.090	-.085	-.102	-.162	-.247	.173	.334*	.002	.204

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N/V	.363*	.325	.305	.298	.328	.196	.235	.068	.242

N = 35

$r_{.05} = .333$

$r_{.01} = .429$

*significant at .05 level

Figure 15. Hypothesis B: Zero order correlations for OSU Section B Males.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N/V	-.176	.112	-.165	.039	-.152	-.091	.136	.266	.248

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N/V	.426*	.165	.118	.029	.297	.110	-.053	.191	.304

N = 23

$r_{.05} = .413$

$r_{.01} = .525$

*significant at .05 level

Hypothesis B and the Two Groups of Females

As Figures 16 and 17 show, there were no significant values of r among the section A females, and one significant value, Intellectual Efficiency, among the section B females. The findings presented in Figures 16 and 17 lead to the acceptance of hypothesis B among the females.

Figure 16. Hypothesis B: Zero order correlations for OSU Section A Females.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N/V	.007	.058	-.043	-.034	-.076	-.160	-.140	-.074	-.051

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N/V	-.124	-.068	-.151	-.141	-.021	-.143	-.027	-.077	-.040

N = 98

$r_{.05}$ = .198

$r_{.01}$ = .259

*significant at .05 level

Figure 17. Hypothesis B: Zero order correlations for OSU Section B Females.

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc
N/V	-.102	-.226	-.220	-.247	-.102	-.246	-.168	-.201	.027

	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
N/V	-.241	-.010	.026	-.183	-.112	-.270*	-.053	-.095	.243

N = 57

$r_{.05}$ = .261

$r_{.01}$ = .338

*significant at .05 level

A Discussion of Findings for Hypothesis B

In this analysis the discrepant achievement variable took the form of N/V where N = numerical achievement in physical science and V = verbal achievement in physical science. In this way overall academic achievement is held constant and subjects are seen as either low numerical-high verbal indicated by small values of N/V, or high numerical-low verbal as indicated by large values of N/V.

The Pearson product-moment r was calculated for each personality trait as it related to N/V. The summary of significant values of r is given in Figure 18. Of the 72 values of r computed (18 in each of the four sub-divisions), in the testing of hypothesis B, one would expect to find about four significant values due to chance alone. It is evident from an examination of these results as summarized in Figure 18 that the number of significant relationships is the same as that expected from chance, and thus the data do not strongly suggest a relationship between personality and differential achievement. However, two less obvious aspects of the findings for hypothesis B merit consideration.

First, Figures 14 and 17 reveal six values of r which are "almost" significant at the .05 level. In Figure 14 the values for Good Impression and Communality and in Figure 17 the values for Social Presence, Sense of Well Being, Tolerance, and Femininity

Figure 18. Summary of findings for Hypothesis B indicating those personality traits which are significantly correlated with N/V at the .05 level

	Do	Cs	Sy	Sp	Sa	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe
OSU Section A Males							+			+								
OSU Section B Males										+								
OSU Section A Females															-			
OSU Section B Females																		

NOTE: The sign indicates the sign of the correlation coefficient

Figure 19. Signs of the correlation coefficients between personality and discrepant achievement

	Do	Cs	Sy	Sp	Wb	Re	So	Sc	To	Gi	Cm	Ac	Ai	Ie	Py	Fx	Fe	Sa
Males, Section A	+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Males, Section B	-	+	-	+	-	+	+	+	+	+	+	+	+	+	-	+	+	-
Females, Section A	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Females, Section B	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	+	-

NOTE: The sign indicates the sign of the correlation coefficient

are almost significant at the .05 level. This information tends to be regarded as evidence in favor of the rejection of hypothesis B and the consequent conclusion that personality is related to verbal-numerical discrepant achievement. Secondly, a consideration of the signs of the r values for the four tests of hypothesis B reveals an unusual distribution. An examination of Figure 19 indicates a large number of positive valued r's among the males while among the females the results are just the reverse. One would expect equal numbers of positive and negative valued correlation coefficients if chance were the only factor operating. This rather large deviation from the chance expectation, and the fact that several values of r are almost significant at the .05 level strongly suggest that the results for hypothesis B are not due solely to chance.

Comparison of the Verbal-Numerical Classification Criterion Used in this Study to that Employed by the Scholastic Aptitude Test

Pearson product-moment correlation coefficients were computed between the two measures of achievement used in this study and the two measures of aptitude employed in the Scholastic Aptitude Test (SAT), for the purpose of comparing the verbal-numerical classification criterion employed in this study to that used in the SAT. The degree of similarity between these two criteria is reflected in the relationship among the values of four correlation

coefficients as discussed previously on page 46. For example, suppose that the two measures of achievement in physical science are internally independent (i.e., verbal achievement in physical science has no relationship to numerical achievement in physical science as measured in this investigation), then the correlation coefficient between verbal achievement in physical science (v), and numerical achievement in physical science (n) will have a value of zero (i.e., $r_{v, n} = 0$). Suppose further that the same internally independent relationship exists between the SAT verbal (V) and mathematical (M) scores (i.e. $r_{V. M.} = 0$). Finally, suppose that the verbal-numerical classification criterion for achievement in physical science is identical to the verbal-mathematical criterion used for the SAT. Under these conditions, one would expect to find a maximum value (i.e., $r_{v, V} = 1$) for the correlation coefficient between verbal achievement in physical science as used in this study (v), and verbal aptitude on the SAT (V). Similarly a maximum value for the correlation between numerical achievement in physical science (n) and mathematical aptitude on the SAT (M) would be expected (i.e., $r_{n, M} = 1$). Finally, since it was postulated in this example, that verbal and numerical measures were independent, one would expect the values of all possible correlation coefficients between dissimilar measures to be zero. Thus the correlation between verbal achievement in physical science and mathematical aptitude on the SAT would

be zero ($r_{v, M} = 0$). The correlation between numerical achievement in physical science and verbal aptitude on the SAT would be zero ($r_{n, V} = 0$).

To summarize the results of this idealized example, if the two measures, verbal and quantitative were internally independent in both this study and on the SAT (viz. the correlations between different measures on the same instrument were zero, $r_{n, v} = 0$ and $r_{M, V} = 0$), and if the classification criterion in this study and on the SAT were identical; then one would expect the two correlations between like measures on different instruments, $r_{n, M}$ and $r_{v, V}$ to have high values and the two correlations between unlike measures on different instruments $r_{n, V}$ and $r_{v, M}$ to have low values. The extent to which the values of the respective intercorrelations parallel this idealized example is indicative of the similarity between the two verbal-numerical classification criteria.

The four correlations $r_{n, M}$, $r_{v, V}$, $r_{n, V}$ and $r_{v, M}$ were computed for each of the four population subdivisions and the respective values are indicated in Figure 20. Since SAT scores were not available for all of the students included in this study, the sample sizes for the two by two matrices in Figure 20 were smaller than for other calculations in this study. SAT scores were available for 74 of the 133 students in section A and for 47 of the 80 students in section B.

Figure 20. Correlations between the verbal-numerical achievement criterion used in this study and that of the Scholastic Aptitude Examination

		M	V
OSU	n	.673	.279
Sec A	v	.441	.378
Males			
N = 18			
$r_{.05}$ = .464			

		M	V
OSU	n	.436	.596
Sec B	v	.157	.826
Males			
N = 10			
$r_{.05}$ = .631			

		M	V
OSU	n	.678	.374
Sec A	v	.523	.314
Females			
N = 56			
$r_{.05}$ = .263			

		M	V
OSU	n	.652	.301
Sec B	v	.429	.301
Females			
N = 37			
$r_{.05}$ = .324			

		M	V
Key	n	$r_{n, M}$	$r_{n, V}$
	v	$r_{v, M}$	$r_{v, V}$

M = SAT mathematical aptitude

V = SAT verbal aptitude

n = numerical achievement in physical science

v = verbal achievement in physical science

As can be seen from Figure 20 the value of $r_{n, M}$ (see key at bottom of Figure 20) is greater than the values of $r_{n, V}$ and $r_{v, M}$ in seven of the eight cases. Thus it is concluded that numerical achievement in physical science bears a very close relationship to mathematical aptitude on the SAT. Examination of the values of $r_{v, V}$ indicates that $r_{v, V}$ exceeds $r_{v, M}$ and $r_{n, V}$ in only three of the eight cases and thus it would appear that verbal achievement in physical science is a different kind of measure than the SAT verbal aptitude.

Summary of Findings

The two interpretations of the relationship between personality and achievement, i.e., hypotheses A and B were tested in each of the four population subdivisions. The test of hypothesis A involved the computation of 36 Pearson product-moment correlation coefficients in each of the four subdivisions. At the .05 level of probability, one would expect to find, from chance alone, at least two significant values of r in each 36 values of r. Hypothesis A was rejected in those cases where the proportion of significant values of r exceeds two in 36, and led to the conclusion that academic achievement and personality are related.

Since the test of hypothesis B involved the computation of 18 instead of 36 values of the Pearson r, rejection occurred in those instances where the proportion of significant values of r exceeded one in 18.

Other factors which tended to influence the conclusions reached in this study were the distribution of the signs of the correlation coefficients in the tests of hypothesis B, the number of values of r which were "almost" significant in the tests of hypothesis B, and the difference in significant findings between the males and females in the tests of hypothesis A.

The results of the tests of the two hypotheses, A and B, in

the four population subdivisions are summarized in Figure 21.

The summary includes the total number of relationships tested (i.e., the number of correlation coefficients computed), the number of significant r's expected from chance, the number of relationships found to be significant at the .05 level of probability, and a descriptive evaluation of the conclusions based upon the discussion in this chapter.

The comparison of the verbal-numerical criterion utilized in this study to that used in the Scholastic Aptitude Test indicated that numerical achievement in physical science as defined in this study is highly correlated with mathematical aptitude as measured with the SAT and that verbal achievement in physical science, as defined in this study, is not highly correlated with verbal aptitude as measured with the SAT.

The general hypothesis, that verbal and numerical achievement in physical science are related to personality as assessed with the CPI, has been supported by the findings presented here, and has been shown to be consistent with similar findings reported in the literature. When the four population subdivisions are considered in total, the number of significant findings for hypothesis A is twice that expected from chance alone. In the results for hypothesis B the resulting anomolies among the signs of the Pearson r's cannot be explained from chance variations. The findings presented in this

Figure 21. Summary of hypotheses testing

	Hypothesis	No. of r's computed	No. of significant r's expected from chance	No. of significant r's	Conclusion in terms of the extent to which the findings support the general hypothesis that academic achievement is related to personality
Males Section A	A	36	2	3	Weak support
Males Section B	A	36	2	2	No support
Females Section A	A	36	2	8	Strong support
Females Section B	A	36	2	3	Weak support
Males Section A	B	18	1	2	Moderate support (see p. 61 for discussion)
Males Section B	B	18	1	1	Moderate support " " " " "
Females Section A	B	18	1	0	Moderate support " " " " "
Females Section B	B	18	1	1	Moderate support " " " " "

study considered against the vast array of related studies reported in the literature were interpreted as strong evidence in support of the notion that personality factors play an important role in academic achievement.

V. CONCLUSIONS, RECOMMENDATIONS AND IMPLICATIONS

Conclusions

The general hypothesis asserted in this study was that personality is related to verbal and numerical achievement in college level physical science. Personality was assessed by means of the California Psychological Inventory (CPI), and verbal and numerical achievement in physical science were measured using the midterm and final examinations given in the physical science course at Oregon State University. This general hypothesis was interpreted in two ways, designated respectively as hypothesis A and B. Hypothesis A stated in the null form is: there is no significant correlation between verbal achievement in physical science and personality; and there is no significant correlation between numerical achievement in physical science and personality. Hypothesis B stated in the null form is: there is no significant correlation between the ratio of numerical achievement in physical science to verbal achievement in physical science and personality.

The tests of these two interpretations, hypotheses A and B, assumed the form of two matrices of intercorrelations between personality and achievement. Hypotheses A and B were tested four times, since the population was divided into four parts.

Each test of hypothesis A involved the computation of a two by 18 matrix of intercorrelations between the 18 CPI factors and the verbal and numerical achievement scores in physical science. Stated in its null form, Hypothesis A is: none of the 36 correlation coefficients between personality and achievement will be significant at the .05 level of probability.

The tests of Hypothesis B were similar to those of Hypothesis A but differed in that they involved a one by 18 matrix. The one by 18 matrix was the result of using the verbal and numerical achievement scores in physical science to form the derived quantity N/V, termed discrepant achievement.

In the four tests of hypotheses A and B, acceptance or rejection was based upon the number of significant values of the product moment correlation coefficient which occurred in excess of that expected from chance.

Hypothesis A was rejected in three out of the four cases, and this result led to the conclusion that verbal and numerical achievement in physical science are related to personality. The results of the four tests of Hypothesis A are summarized in Figure 21.

Hypothesis B was accepted in all four of the null tests; however, further interpretation of the findings in these four tests resulted in the conclusion that discrepant achievement is related to personality. The detailed discussion of the interpretation and

conclusions for Hypothesis B are presented in the previous chapter in the section entitled "A Discussion of Findings for Hypothesis B." A brief summary of the results for Hypothesis B is presented in Figure 21.

The findings for both of the major hypotheses, A and B, support the general notion set forth in this study that personality is related to certain aspects of academic achievement. In addition, these findings have been shown to be generally consistent with the literature.

The results obtained in this study uphold the generally accepted notion stated in the words of Butcher and Ainsworth (1963, p. 276) that " . . . it is widely recognized that personality factors play a part in determining school attainment . . . " Furthermore, the results of this study and of those reported in the literature suggest the existence of a relationship between personality and academic achievement. The results reported here are in accord with those in the literature in suggesting that there may be relationships between certain groups of constellations of personality traits and specific modes of academic achievement. The results of this study further corroborate those in the literature in suggesting the need for clarification of the discrepant achievement concept.

As was noted in the review of the literature, the notion of discrepant achievement has resulted in a number of studies which

have produced findings of considerable significance and further studies of similar design would seem to hold promise of producing fruitful results. The results of this study also suggest that the notion of discrepant achievement would seem to hold promise as a conceptual device in further research. Two reasons for this are evident. First, as previously noted, the findings for Hypothesis B were interpreted to be supportive of the discrepant achievement notion. Secondly, in the findings for Hypothesis A, an inspection of Figure 12 indicates that, for the most part, those personality traits which were significantly correlated with verbal achievement are different from those traits which correlate significantly with numerical achievement. This finding lends support to the notion that perhaps there exist various constellations of personality traits which are related to specific forms of intellectual acheivement. In addition, Figure 12 indicates only two instances where the same personality trait correlated with both verbal and numerical achievement, and in both of these cases the correlation of the trait with verbal achievement was positive while its correlation with numerical achievement was negative.

As previously mentioned, a review of the literature revealed many conflicting results in the work concerned with the relationship between personality and overall academic achievement. Some improvement in consistency was noted in those research efforts which

placed certain restrictions upon the measurement of achievement. The shortcomings in using grade point average as an achievement criterion were discussed.

On the basis of the findings from this study and those of similar studies, which have been reported in the literature, what directions are indicated for further research? It would seem that the most promising conceptual basis for future research design is embodied in the notion of discrepant achievement. Evidence, both from the results, of this study, and from the literature, suggest that such a notion may prove fruitful in providing an increased understanding of the relationship between personality and academic achievement. Consequently, the recommendations for future research are based upon the notion of discrepant achievement as it relates to the teaching of science.

Recommendations

On the basis of the foregoing conclusions and discussion, the following recommendations for further research would seem to be in order.

1. It is suggested that verbal and numerical achievement be measured with a standardized instrument and that the same instrument be administered to all subjects in the population under investigation.

2. It is reasonable to suspect that a portion of the variance in achievement may be caused by the subjects' interest in physical science, and hence it would be desirable to measure interest in physical science, by some means and hold it constant in the determination of the personality-achievement correlations. The method of partial r's is suggested here.
3. Anxiety toward mathematics could be measured and treated in a manner similar to interest as suggested in Number 2 above.
4. Finally, replication of this study is strongly recommended for the purpose of determining the extent to which these results can be generalized to other science courses and populations and grade levels.

Implications

When one considers the relationship between the progress of science and the occupations in our culture during the past, it is clearly evident that the need for highly trained specialists in the sciences has continued to increase. Assuming that this trend continues, the need for more effective education in the sciences will continue as the demand for more and more specialists continue to rise.

While much attention has been given recently to careful and

clever design of new science courses at all levels of education, relatively little, if any, consideration has been given to the relationship between the social-psychological environment of the learner and the content, structure and objectives of these courses. Rarely is the student provided an opportunity to voice his reactions or feelings about science classes and to this extent science education proceeds in ignorance of a true evaluation of its objectives. For example, it is clear that the kinds of student experiences mentioned in Chapter II of this thesis probably are not likely to result in stimulating a life-long interest in and understanding of science. To promote these desired interests and understandings it would seem that science curriculum designers need to give more careful consideration to the psychology of the learner. Marshall and Burkman (1966, p. 105) have said in this regard:

> There is a likelihood that the present courses are not reaching some students on a basis entirely apart from such obvious factors as intelligence. It may very well be that there is more than one type of human mind in terms of one's ability to learn science, and that programs based upon the rationale of the courses recently developed do not reach all of the various psychological types. Should this be the case, it may become necessary to design completely new courses with different appeals to different types of students. This could result in three or four courses for a given science subject, different from one another in approach rather than simply in level of sophistication or rigor. Conceivably, future students will be grouped on the basis of measureable psychological characteristics in addition to intelligence, and the means of classifying students may be derived from our efforts to evaluate existing science courses.

While the end of a decade approaches in which science curriculum development has occurred on an unprecedented scale, the percentage of high school students enrolled in the physical sciences continues to decline. In discussing this issue Watson (1967, p. 26) states:

> All of the groups (curriculum development groups) are composed of sincere and competent individuals. Yet it is surprising that most groups have started by announcing that some subject area was to be their instructional medium. To start by considering the interests and abilities of the pupils and their general image of science within society . . . would seem to be more appropriate.

It may well be that a careful investigation of the complex relationship between the learning of subject matter and the sociological-psychological aspects of the learner could be instrumental in the development of more effective programs in science education and hence could ultimately be a factor in alleviating the shortage of qualified persons trained in the physical sciences.

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APPENDIX

August 31, 1966

Educational Testing Service
Professional Assistance Department
4640 Hollywood Boulevard
Los Angeles 27, California

Dear Sir:

Your organization responded so quickly and was so very helpful to my colleague Mr. Leroy McIntosh of Oregon State University that it is upon his recommendation I am addressing my request for assistance to you.

As part of a study being conducted at Oregon State and Utah State Universities we are attempting to classify test questions appearing on midterm and final examinations as either verbal or numerical (mathematical) in a manner similar to the CEEB questions.

We are interested in obtaining information relating to the criteria used in making this kind of a classification for the CEEB examination in the hope that it may be adapted to our situation.

Would it be possible for you to furnish me with the criteria or technique you use in verbal-numerical classification of test items.

Thank you very much for whatever assistance you may render in this matter.

Most respectfully yours,

Walter L. Saunders
Ass't. Professor of Education

WLS:mjw

EDUCATIONAL TESTING SERVICE WESTERN OFFICE

[illegible] Street
[illegible], California 94704
Tele[illegible] Area Code 415 845-0950

September 13, 1966

Walter L. Saunders
Assistant Professor of Education
Utah State University
Logan, Utah 84321

Dear Mr. Saunders:

Your inquiry regarding the criteria used in the classification of test items into either verbal or numerical categories is a very simple one to understand but, possibly, very complicated to answer.

After considerable cogitation about how much of an answer you really want, we decided to refer your letter to one of our test development people, all of whom are located in our Princeton office. Accordingly, I have forwarded your your letter, via air mail, to Mr. Thomas Donlan, Assistant Director, Test Development, ETS, Princeton. We feel that he is the person best qualified to answer your question on both a technical and a lay level. You should receive a reply from him soon.

If you are eventually not able to obtain the information you desire, please advise me--perhaps in more explicit detail--and we'll try again.

Sincerely yours,

Redacted for Privacy

Edward R. Tibby
Professional Associate
Advisory Services

ERT/kc
cc: Mr. Donlon

EDUCATIONAL TESTING SERVICE PRINCETON, N. J.

Test Development Division

September 15, 1966

Mr. Walter L. Saunders
Assistant Professor of Education
Utah State University
Logan, Utah 84321

Dear Mr. Saunders:

Mr. Edward Tibby of our Western Office has sent me your letter of August 31, in which you inquire about item classification systems. Your letter says, "...we are attempting to classify test questions appearing on midterm and final examinations as either verbal or numerical (mathematical) in a manner similar to the CEEB questions." This leaves me puzzled, for we do not have any stated criteria other than the extremely obvious one: verbal questions test reading and vocabulary skills, numerical questions test mathematical skills.

My own internal resolution of my puzzlement is to suppose that (a) you believe our materials to be a more complex blend of the verbal and mathematical than they in fact are, or (b) that you really want to know how we categorize within the broad domains of verbal—mathematical. I would be happy to hear further from you on this point. If (a) is the situation, it has seemed to me that this is best handled by sending you a copy of our candidate's booklet for the SAT, which provides a sample test. As you see from an inspection of its instances of verbal and mathematical materials, there is little trouble telling them apart.

I will be glad to provide further information if (b) is in fact the situation, so do not hesitate to write again.

Sincerely,

Redacted for Privacy

Thomas F. Donlon
Assistant Director
Test Development Division

TFD/du
enc.
cc: Mr. Tibby WO

September 27, 1966

Mr. Thomas F. Donlon
Assistant Director
Test Development Division
Educational Testing Service
Princeton, New Jersey 08540

Dear Mr. Donlon:

Thank you very much for your reply of September 15, 1966.

Your puzzlement is solely due to my failure to be more specific in my original inquiry.

From the copy of the candidate's booklet for the SAT, which you kindly sent, it is clear that numerical or mathematical items always involve mathematics as a necessary requisite for arriving at the correct answer to the test item.

The problem seems to arise in my mind when I attempt to classify items on existing midterm or final examinations as either verbal or numerical. How, for example, would one classify the following test items?

1. "According to Boyles' Law
   a. volume varies inversely with pressure
   b. temperature varies inversely with pressure
   c. volume varies directly with pressure
   d. volume is independent of pressure
   e. volume depends only on the temperature"

2. All are units of mass except
   a. ounce
   b. kilogram
   c. pound
   d. milliliter
   e. milligram

3. The mole is
   a. the weight of a substance in grams equal to its molecular weight
   b. the actual number of atoms in 22.4 liters of any gas at STP
   c. the weight of a molecule of a compound
   d. an abbreviation for the word molecule.

4. In 1911 Rutherford bombarded gold foil with alpha particles, observing that approximately one particle in 100,000 was deflected when passing through approximately 1000 atoms. From this investigation, Rutherford concluded that
   a. the positive charge and most of the mass is concentrated in a small volume
   b. uncharged atoms are composed of equal numbers of electrons and protons
   c. electric charge is uniformly distributed throughout the volume of the atom
   d. electrons are arranged in circular orbits whose energy levels increase with distance from the nucleus.

A further point of confusion for me is that, in a sense, words and sentences are symbolic representations of mental processes; but the same can be said of the mathematician's shorthand, thus making the mathematical verbal distinction a very difficult one. It is probably the case that I am making this problem more difficult than it really is. Perhaps the two-category classification system is not an exhaustive one and consequently some test items fall into neither group.

Thank you very much for your previous thought and action on this matter and I will be much obliged for whatever answer you may give to my thoughts.

Sincerely,

Walter L. Saunders
Ass't. Professor of Education

WLS:mjw

EDUCATIONAL TESTING SERVICE PRINCETON, N. J.

Test Development Division

October 6, 1966

Professor Walter L. Saunders
Department of Secondary Education
College of Education
Utah State University
Logan, Utah 84321

Dear Professor Saunders:

Your letter of September 27, 1966 nicely clarifies your problem and thereby reveals my inability to help you with it. We at ETS do not know how to classify the kinds of mathematical-scientific problems which you demonstrate. I feel resonably certain that we would call them all "verbal," but this only because they do not require computation. Even this criterion gets waived on occasion: we may use a reading comprehension passage based on physics material and test reading comprehension of, say, radioactive half life by requiring the solution of a simple proportion.

We have material that asks questions about a graph-and-passage unit that presents some information verbally, some graphically. In general, all of our graphs and charts are a blend of verbal and mathematical skills. Life is perplexing; taxonomy difficult.

One datum may help you in your quest. I think you are correct in remarking the fundamental similarity between verbal and mathematical symbol-systems. They are both language in a sense, and both may be anticipated to reflect similar underlying abilities. In fact, (my datum coming) the two tests on the SAT correlate around .70. If such clearly disparate question types tap such similar abilities, a more complex question must be very hard to categorize.

Thank you for writing and I hope my datum helps.

Sincerely,

Thomas F. Donlon
Assistant Director
Test Development Division

TFD/du