THE PERSONALITY FACTOR OF RIGIDITY AS AN ELEMENT IN THE TEACHING OF THE SCIENTIFIC METHOD

By

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CHAPTER I

INTRODUCTION

Purpose of the Study

The main purpose of this investigation was to compare a group of individuals classed, on the basis of an arithmetic technique,[1] as relatively rigid in their thinking process with a group of individuals categorized as relatively non-rigid, on the basis of an arithmetic technique, in their thinking process as to: (1) their reaction to various aspects of the scientific method; (2) the comprehensiveness of their pattern of thinking; and (3) their performance on a Biological Science laboratory study in the normal classroom situation.

As much of the work of this investigation stems from the work of Rokeach[2] on generalized mental rigidity as a factor in ethnocentrism, a subsidiary purpose developed. The subsidiary, though important, purpose of this investigation is to check the work of Rokeach so as to determine to what extent his work is valid.

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[1] See Chapter II.

[2] Milton Rokeach, "Generalized Mental Rigidity As A Factor in Ethnocentrism," The Journal of Abnormal and Social Psychology, 43:259-278, July, 1948.

The Concept of Rigidity

This study was projected because an aspect of psychology, the concept of rigidity, seemed to give an insight into the question of why some students appear to be able to understand and utilize the scientific method and others do not. It is the opinion of the writer that resorting to the major theories and concepts of psychology would offer a good springboard to the understanding and possible solution of many educational problems. As the general field of psychology deals with responses to any and every kind of situation that life presents, including experiences and behavior of human beings in response to educational situations, this would be of special significance to problems dealing with learning and teaching. Many teachers in the field are too impatient with theory in the basis sciences. They prefer to investigate specific practical problems without relating these problems to basic theoretical concepts. There is little thought given to the idea that the development of educational science depends primarily upon the formulation, extension, and revision of conceptual systems that have been devised to explain learning.

One of the foremost problems in the development of educational science, or of any science, is that concerned with the building of a system of concepts. For it is through a conceptual

system that there is gained the logical machinery by which the elements of experience are tied together in a related manner. It should be recognized, however, that while it may be possible to impute certain observable phenomena to a particular conceptual scheme, if the concept does not represent anything real, then the results, in terms of the concept, are meaningless. Hull[3] states that a theoretical system consists of such elements as: definition of essential terms, a set of postulates, a body of interrelated theorems derived from the postulates and stated in such terms that they can be empirically verified. The concept of rigidity, which has been developed by the foregoing criteria, is a basic concept utilized in such problems of personality structure as are presented in this study.

Definition and status of the concept of rigidity. One of the elements of a theoretical system, as presented by Hull[4] is a definition of essential terms. Werner[5] in his paper on a critical

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[3] Clark Hull, Mathematico-Deductive Theory of Rote Learning (New Haven: Yale University Press, 1940), pp. 1-13.

[4] Ibid.

[5] Heinz Werner, "The Concept of Rigidity: A Critical Evaluation," Psychological Review, 53:43-52, January, 1946.

evaluation of the concept of rigidity, states that there has arisen a general ambiguity as to the meaning of the term "rigid." One of the reasons for this lack of clearness is the fact, as he states, some define the term structurally and others define it functionally. The structural definition has taken on a literal—physical—meaning, expressed within the framework of Lewinian topological psychology. An exponent of this definition, Kounin,[6] employing Lewin's theory of personality structure, formulated an hypothesis of rigidity as a quasi-material property of mental organization. It would be profitable to quote Kounin here. He states:

> The concept of rigidity has its place in a series of interrelated statements and constructs which are postulated in topological and vector psychology. Briefly, the "person" is said to be structured and differentiated into parts. The unit of structure is coordinated to a geometrical region, or "cell," which occupies a certain position among other regions. The psychological environment in which a person behaves is also structured into regions. Behavior is said to be a resultant of certain forces functioning and relating the personal and environmental structures. The structural and positional properties constitute topological psychology. The functional relationships and forces which determine the behavior that occurs within the given structure make up vector psychology.
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> The construct of rigidity deals with the closeness of the functional relationships between cells of the person; in

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[6] J. S. Kounin, "Experimental Studies of Rigidity," Character and Personality, 9:251-272; 273-282, June, 1941.

> other words, it refers to that property of the functional boundary between the cells of the person which represents the relative independence (degree of segregation) of different regions of a person. Occurrences in one region may have quite different effects upon other regions. A change in region A of a person may produce more change in a region B than the same amount of change in a region X produces in a region Y; i.e., tension may spread more easily from region A to region B than from region X to region Y. There may be such differences in rigidity of the boundary between different regions of the same individual and differences in rigidity between comparable regions of different individuals.[7]

Taken in its functional sense, that is, by the ways in which rigidity is manifested overtly, rigidity can be referred to as sluggishness in variation of response,[8] fixation of response,[9] lack of variability,[10] perseveration,[11] inability to change one's set when the objective conditions demand it, the inability to restructure a field in which there are alternative solutions to a problem in order

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[7] Ibid., pp. 251-252.

[8] Warner, op. cit., pp. 43-52.

[9] I. Krechevsky and C. H. Hanzik, "Fixation in the Rat," University of California Publications in Psychology, 6:19-26, 1932.

[10] I. Krechevsky, "Brain Mechanisms and Variability," Journal of Comparative Psychology, 23:121-130, August, 1937.

[11] C. E. Spearman, Abilities of Men: Their Natures and Measurement (New York: Macmillan, 1927).

to solve that problem more efficiently.[12] Werner[13] defends the functional definition as the more fruitful of the two and it is in this sense that the concept of rigidity is used in the discussion here presented. While it is simpler to think of rigidity from the behavioral, the functional, point of view, one should also keep in mind the theoretical concept of the psychological structure and differentiation of mental organization from which this behavior seems to stem. In line with this latter thought it should also be noted that stereotyped actions cannot always be directly derived from the rigidity of the boundaries of a person's psychological structure. Such elements as security, fear, and the time element may lead to phenomenologically rigid behavior that may not be due to structural rigidity of the psychological boundaries. Benjamin[14] has stated that the stage of scientific theory is reached when it is possible to interpret particular phenomena in terms of the operation of more fundamental, underlying factors. In biology,

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[12] Rokeach, op. cit., p. 259.

[13] Werner, op. cit., pp. 43-52.

[14] A. C. Benjamin, An Introduction to the Philosophy of Science (New York: Macmillan, 1937), pp. 214-218.

for example, the description of particular phenomena (inheritance of physical characteristics) are derived from a general theory (theory of the gene). Explanations of phenomena can be on various levels. Some theories are of a higher order than others. The higher the order of theory the more kinds of events that can be subsumed under that particular set of premises. The advantage of a higher-order theory is that if the higher-order theory is known, the lower-order theories and their derivatives are also known. Figure 1 (modified from Kounin)[15] shows the explanatory power of the concept of rigidity in terms of the number of events which it is possible to derive from it. It is noted in Figure 1 that the lowest level concerns the observable facts. Explanations of these facts are on the "descriptive law" level which involves the postulation of some kind of ability. The descriptive laws do not go much above the facts, but repeat on the conceptual plane what has been found on the factual level. Higher level theories, such as concrete-mindedness and comprehensiveness are on a higher level because they permit the derivation of more events. The rigidity theory is on still a higher level because it leads to still

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[15] Kounin, op. cit., pp. 273-282.

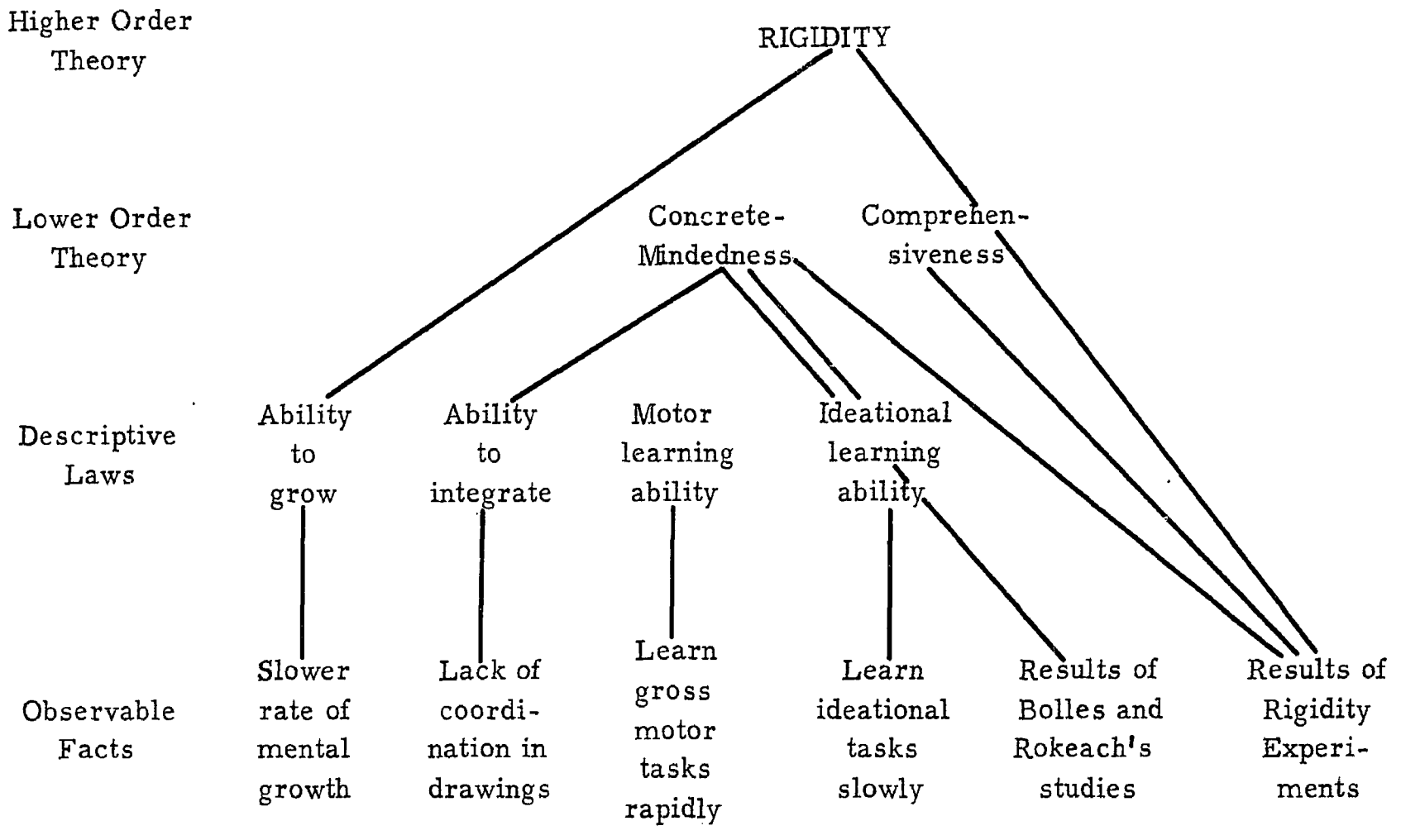

FIGURE 1

DIAGRAMMATIC REPRESENTATION OF THE EXPLANATORY POWER OF THE CONCEPT OF RIGIDITY

more derivations. It permits the postulation of concrete-mindedness and comprehensiveness. It allows for the prediction of the results obtained in the research of Kounin[16] and Rokeach.[17] The present report is also based upon predictions involving comprehensiveness on a lower level and of the concept of rigidity on the higher level.

Review of the literature. Further development of the concept of rigidity can be taken up through a review of the literature on the subject. A consideration of the literature in this area showed that the literature could be broken down in terms of the following aspects of rigidity: (a) rigidity on the clinical and genetic level; and (b) the general rigidity factor.

(a) Rigidity on the clinical and genetic level.

Much of the work on rigidity has been from the aspect of brain injured individuals, and a comparison of normal with feeble-minded individuals. Werner[18] has also worked with reference to

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[16] Ibid., pp. 251-272, 273-282.

[17] Rokeach, op. cit., pp. 259-278.

[18] Werner, op. cit., pp. 43-52.

maturity and immaturity of individuals. He distinguishes the following three instances:

1. The "regions of personality" of an immature individual are little differentiated; it is therefore to be expected that mutual interference, in the form of perseveration and stereotypy, should occur frequently.

2. In a mentally growing organism the regions become more differentiated; a differentiated behavior emerges, varying with changes of situation (functional stability and flexibility).

3. If regions are severed from one another, intercommunication ceases, and a state of rigidity, due to "isolation" prevails. Only in this particular instance does the concept of rigidity approach the structural terms as used by Kounin.[19]

Werner[20] takes the position that rigidity is in reality a multiform and not a unitary trait, especially when one considers that there are differing forms of feeblemindedness, which differ from each other in their mental organization. Werner and Strauss[21]

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[19] Kounin, op. cit., pp. 273-282.

[20] Werner, op. cit., pp. 43-52.

[21] A. A. Strauss and H. Werner, "Experimental Analysis of the Clinical Symptom 'Perseveration' in Mentally Retarded Children," American Jour. Mental Deficiency, 17:185-188.

have shown that different kinds of rigidity can be distinguished which vary in quantity and quality with organismic conditions. Conclusions drawn by various authors from experiments with children of unspecified forms of mental deficiency may be biased depending on the selection of subjects. Werner[22] presented, diagrammatically, two types of rigidity with reference to normal behavior. These types are shown in Figure 2. In terms of regions of personality three forms of relationships between regions A and B may be distinguished: (1) fusion of A and B resulting in primitive and subnormal rigidity of young children and generally feebleminded persons; (2) differentiation of a common sphere into two regions, A and B, communicating with one another with a resulting normal variability of response a_1 and a_2, according to change of situation; and (3) separation of regions A and B and therefore abnormal rigidity.

In a paper presented in 1943 Goldstein[23] expressed the view that brain injured patients display two kinds of rigidity called primary and secondary rigidity. Both forms are basically due to

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[22] Werner, op. cit., pp. 43-52.

[23] K. Goldstein, "Concerning Rigidity," Character and Personality, 11:209-226, June, 1943.

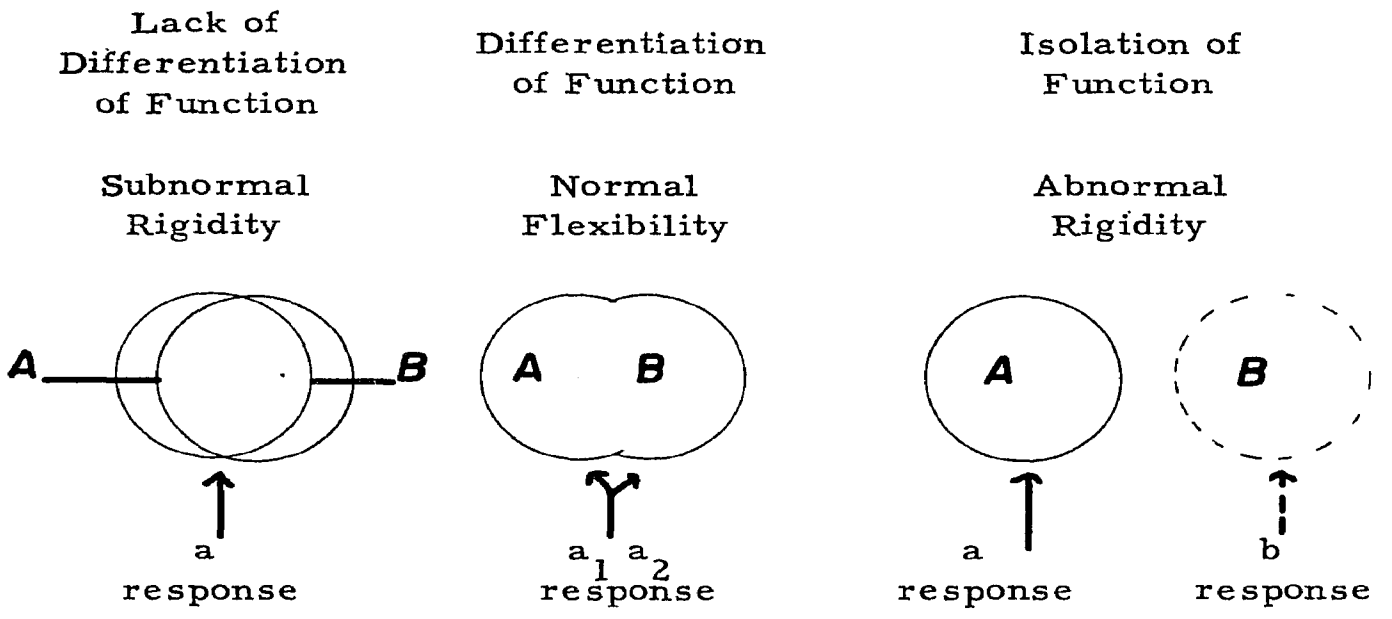

FIGURE 2

DIAGRAMMATIC REPRESENTATION OF SUBNORMAL AND ABNORMAL RIGIDITY

"isolation": ". . . rigidity appears if a part of the central nervous system that is anatomically and functionally separated from the rest of the system is exposed to stimulation." Primary rigidity is independent of an impairment of higher mental processes. It is a basic lack of ability to change from one "set" to another. This deficiency becomes apparent only if the patient attempts to shift from one activity to a task that is not related to that activity. The difficulty does not lie in the task itself; in general the patient is quite capable of solving any of these tasks even if a higher level

of abstraction is demanded. This type of primary rigidity has been observed in patients with lesions of the sub-cortical apparatus. A secondary form of rigidity is a result of the impairment of thinking. This rigidity appears only if the task is too difficult; the patient, in order to avoid a complete breakdown, sticks to the task he has solved before, repeating it over and over. Rigidity here is a secondary phenomenon; it is a means to escape from a frustrating experience. There are other means of escape, such as distractibility. Unable to master the situation the patient shifts from one part of the field to another. Goldstein[24] believes that rigidity of the feebleminded is also due to this mechanism: the mentally defective, not being able to cope with abstract tasks, becomes perseverative and distractible.

Some of the writings of Kounin[25] can be profitably explored here in relation to the concept of rigidity. Kounin in this series of papers reveals the concept of rigidity, particularly as applied to the theory of feeblemindedness, tentatively formulated by Lewin.[26]

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[24] Ibid.

[25] Kounin, op. cit., pp. 273-282.

[26] K. Lewin, A Dynamic Theory of Personality: Selected Papers (New York: McGraw-Hill, 1935), pp. 209-238.

This theory is based on studies dealing with comparative behavior of feebleminded and normal children. In experiments concerned with the process of satiation, the resumption of interrupted tasks and the substitute values of substitute actions the findings revealed decided differences between the feebleminded and normal children. After becoming satiated with an assigned drawing activity, the feebleminded refused to continue with free drawing, while the normal children did not refuse. The feebleminded exhibited an "either-or" status in that they were either satiated or not satiated, while the normal children were partially satiated. In experiments on resumption of interrupted activities, the feebleminded manifested a greater fixation on goals than did the normal. This was evidenced by their more frequent resumption of interrupted activities. In studies on substitution it was found to be more difficult to create satisfactory substitute goals in the case of the feebleminded than in the case of the normal children. He summarized the differences between the two groups of children as indicating that the feebleminded children behaved more rigidly, i.e., in a pedantic, "all-or-none" "either-or" manner. The construct of rigidity was utilized to derive these differences.

Kounin[27] states that rigidity of overt behavior cannot be directly coordinated with rigidity of the boundaries of the regions making up a person's structure, i.e., with his dynamic rigidity. There are factors other than boundary or dynamic rigidity that may operate to produce phenomenological rigidity. He further states that there are three such uncontrolled factors which may have influenced the results obtained by Lewin:[28] (1) The degree of differentiation of the person. The mental ages and related degrees of differentiation of the feebleminded and normal children used in the experiments were not equated. (2) The degree of differentiation of the relevant areas. Kounin[29] states that, "One can speak of the degree of differentiation 'as a whole,' and the degree of differentiation of particular areas. Two persons may have the same total degree of differentiation, yet one of them may behave in a more stereotyped manner in a particular situation because the relevant and applicable regions are less differentiated

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[27] Kounin, op. cit.

[28] Kounin, op. cit., pp. 252-253.

[29] Ibid., pp. 251-272.

in his case."[30] (3) The security of the two groups (fear of failure, etc.). If an individual feels insecure he may exhibit phenomenologically rigid behavior, not because of his dynamic rigidity but because he is afraid of attempting the new and so cling to what he does know.

Kounin[31] worked on the problem of evaluating the concept of rigidity in terms of developing and measuring the properties of rigidity and to ascertain its validity in theories of age and feeblemindedness. Specifically, with factors such as degree of differentiation and security controlled, can one speak of rigidity of boundaries of regions? If so, can the concept be related to theories of feeblemindedness and of age? Another part of his work was to attempt to ascertain the predictive value of the construct of rigidity and related topological and dynamic aspects. Specifically: does the theory permit one to state the consequences to be obtained in defined conditions? For a complete description of this series of experiments the reader is referred to the papers of

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[30] Ibid., p. 253.

[31] Ibid., pp. 251-272.

Kounin.[32] It is perhaps sufficient to present here the summary and conclusions as Kounin stated them:

> The general conclusion is to the effect that any performance which requires a certain degree of communication between neighboring regions (the degree of communication being inversely proportional to the degree of rigidity) is to such an extent made difficult for the older and/or more feebleminded as far as these experiments permit one to generalize, the phenomenological nature of the performance is unimportant. The task may be predominantly of a cognitive nature . . . of a motor nature . . . or of a volitional nature. If a task is facilitated by a lack of communication between the neighboring regions, such a tas will be more efficiently and accurately performed by an older and/or more feebleminded individual (as indicated by the "transfer of habit" experiment).[33]

There have been a number of approaches used to get at an understanding of the comparative nature of the psychological structure of feebleminded and normal individuals. These approaches have included comparison on standard tests, comparison of the learning ability, and comparative studies of the cognitive processes of both groups. Another type of approach has come from a consideration of general psychological theory, an example of which is the dynamic theory of feeblemindedness that

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[32] Ibid., pp. 252-272, 273-282.

[33] Ibid., p. 271.

has been proposed tentatively by Lewin.[34] The rigidity theory has proved fruitful because it has permitted the derivation of such postulations as concrete-mindedness and the results of the experiments reported above. Studies in rigidity in feebleminded subjects,[35, 36, 37, 38, 39] in brain injured and spastic subjects,[40, 41, 42, 43, 44, 45] and in

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[34] Lewin, op. cit., pp. 209-238.

[35] Goldstein, op. cit., pp. 209-226.

[36] Kounin, op. cit., pp. 251-272.

[37] Lewin, op. cit., pp. 209-238.

[38] Werner, op. cit., pp. 43-52.

[39] Heinz Werner, "Abnormal and Subnormal Rigidity," Journal of Abnormal and Social Psychology, 41:15-24, 1946.

[40] Loc. cit.

[41] Goldstein, op. cit., pp. 209-226.

[42] Strauss and Werner, op. cit., pp. 185-188.

[43] C. B. Cotton, "A Study of the Reactions of Spastic Children to Certain Test Situations," Journal of Genetic Psychology, 58:27-40, March, 1941.

[44] A. A. Strauss and H. Werner, "Comparative Psychopathology of the Brain Injured Child and the Traumatic Brain Injured Adult," American Journal of Psychiatry, 45:1-41, July, 1943.

[45] H. Werner and A. A. Strauss, "Causal Factors in Low Performance," Amer. Jour. Ment. Def., 45:213-218, 1940.

schizophrenia[46] all indicate that concreteness of thinking is usually found in rigid persons.

A number of studies on the effect of decortication on rigidity have been performed. These studies compare the performance of decorticated rats with that of normal rats. Cameron[47] concluded that rats with cortical lesions are inferior to normal rats in learning new problems and in adapting to modifications of old problems. Maier[48] inferred that operated rats are more likely to repeat errors than normal rats. Hamilton and Ellis[49] concluded from their investigations that operated rats were more constant in their behavior than the same animals had been when normal. Krechevsky[50] came to the decision that cortical lesions in rats resulted in less variability and plasticity of behavior.

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[46] J. Kasanin and R. Hanfman, "An Experimental Study of Concept Formation in Schizophrenia," American Journal of Psychiatry, 95:36, July, 1936.

[47] N. Cameron, "Cerebral Destruction in It's Relation to Maze Learning," Psychological Monographs, Vol. 39, No. 1, 1928.

[48] N. R. Maier, "The Effect of Cerebral Destruction on Reasoning and Learning," Journal of Comparative Neurology, 54: 45-75, January, 1932.

[49] J. A. Hamilton and W. Ellis, "Behavior Constancy in Rats," Journal of Genetic Psychology, 42:138, March, 1933.

[50] Krechevsky, op. cit., pp. 121-130.

There has been a number of experiments testing the effect of frequency and repetition on rigidity of behavior. Krechevsky and Honzik[51] in an experiment utilizing rats as the experimental subjects concluded that rats that had overlearned a particular pathway to a goal had thereafter greater difficulty in learning a new pathway. Luchins[52] in an experiment involving experimental increase in rigidity found that he could increase the rigidity on critical problems by giving the subjects more problems designed to establish a set. Rokeach[53] designed and carried out a series of experiments from which he concluded that an increase in perception time seems to result in a decrease in rigidity and also decreases concreteness of thinking.

(b) The general rigidity factor.

A number of workers in the field of rigidity as a personality factor have hypothesized that there is a general rigidity factor which will pervade many of the actions of the individual, both

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[51] Krechevsky and Honzik, op. cit., pp. 19-26.

[52] Luchins, op. cit.

[53] M. Rokeach, "The Effect of Perception Time Upon Rigidity and Concreteness of Thinking," Journal of Experimental Psychology, 40:206-216, April, 1950.

actions that are overt and those that are not apparent on the surface. The work of Fisher[54] on a study involving individuals all of average intelligence, though differing as to normal and abnormal behavior, has for its basic hypothesis a persistent personality rigidity. He states:

> The hypothesis that forms the basis for the measurement procedures utilized in this study is that there are persistent personality rigidity trends which are relatively independent of intelligence. It will be assumed that such rigidity trends reveal themselves in the degree to which any given individual is able to indicate in some behavioral way his ability to utilize alternate modes of response when dealing with problems or situations requiring adjustment. . . . It is important that it be clearly understood to what degree this brief hypothesis really does neglect the complexity of factors involved in rigidity phenomena. One suspects that if sufficiently sensitive measuring instruments were available, it would be possible to analyze rigidity phenomena in many different dimensions. Thus, hypothetically one might be able to measure rigidity as it affects perception of situations, as it affects subjective reactions to situations, and of course as it affects overt behavioral reactions to situations. Furthermore one might be able to describe rigidity in each of these dimensions in terms of a large number of descriptive continua (e.g., quickness with which evoked, degree of persistence after arousal, and degree of generalization). Ideally, it would be well to measure as many of these phases of rigidity as possible. But it has been necessary here to treat the problem in a simpler fashion: to confine postulations to overt behavioral manifestations of rigidity and to limit them to

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[54] S. Fisher, "Patterns of Personality and Some of Their Determinants," Psychological Monographs, 64:1-48, 1950.

> rigidity manifestations conceived to exist on a single restricted continuum. . . .[55]

Fisher's[56] project was based on the following questions: (1) Do individuals show a consistently rigid behavior in various situations? (2) Are there differing kinds of rigidity, if so, what is the importance of each in the personality structure? (3) Do individuals who are in general emotionally restricted show a rigidity of behavior? (4) Does the self analysis of a subject have any relation to rigidity? (5) Do those who are not normal (e.g., neurotic) show specific rigidity trends?

Fisher concluded from his studies that the results implied that personality rigidity manifestations cannot accurately be described in either very specific terms or in very general terms. Fisher states that his data suggest that there are possibly two levels of rigidity: (1) situations involving no emotional threat to the individual; and (2) those situations involving threat to the individual or which question his self esteem. He also states that intelligence seems to have no clear relationship to the character of an individual's rigidity pattern.

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[55] Ibid., pp. 1-2.

[56] Ibid., p. 3.

To summarize Fisher's work[57] in relation to the hypothesis of generalized mental rigidity, while Fisher is operating on the basis of this hypothesis his results do not present any conclusive evidence to indicate either generalized mental rigidity or rigidity in specifics.

The work of Frenkel-Brunswik and Sanford[58] and Levinson and Sanford[59] indicate the possibility that rigidity of personality structure is an all pervasive phase of the personality. These authors indicate that the differences between the prejudiced and non-prejudiced individuals suggest that there would exist similar differences in the manner in which they would solve other types of problems that they would be confronted with.

The basic assumption of the work of Rokeach[60] was that one of the characteristics of ethnocentric thinking is a rigidity

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[57] Ibid., pp. 1-48.

[58] E. Frenkel-Brunswik and R. Sanford, "Some Personality Correlates of Anti-Semitism," Journal of Psychology, 20: 271-291, November, 1945.

[59] E. Frenkel-Brunswik, D. Levinson and R. Sanford, "The Anti-Democratic Personality," Readings in Social Psychology, T. H. Newcomb, Editor (New York: Henry Holt and Company, 1947), pp. 531-541.

[60] Rokeach, op. cit.

and inflexibility of the thinking process. To Rokeach the main problem which suggested itself for investigation was whether this type of rigid thinking operates only in the solution of social problems or whether it is equally characteristic of the ethnocentric individual in his approach to other kinds of problems as well: social or non-social in nature. Rokeach took the position that the individuals' social attitudes may be regarded as that individuals unique solution to the problem of how he will group people into classes and how he will react to these classes. A similar position is taken by Krech[61] who also regards attitudes as problem solving attempts. The hypothesis tested by Rokeach in his work was as follows:

> The rigidity inherent in the ethnocentric persons' solution of social problems is not an isolated phenomenon within the personality but is rather an aspect of a generally persistent personality characteristic which will also manifest itself in the solution of all kinds of problems, even though such problems are completely lacking in social content.[62]

Rokeach labeled this "generally persistent personality characteristic" as a general rigidity factor. In order to test his hypothesis

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[61] D. Krech, "Attitudes and Learning: A Methodological Note," Psychological Review, 53:290-293, November, 1946.

[62] Rokeach, op. cit., p. 259.

he categorized his subjects into two groups: (1) a grouping broken down into those scoring high and those scoring low on the California Ethnocentric Scale; and (2) a group broken down into those individuals manifesting an inability to change from one mental set to another previously followed in the solution of a series of arithmetic problems. The results indicated that those individuals who were high on the California Ethnocentric Scale were also, in a statistically significant ratio, unable to change their mental set in the solution of the arithmetic problems. In other words, those individuals who manifested a rigidity in ethnocentrism also manifested a rigidity in the solution of arithmetic problems, which may be described as a relatively non-social situation.

It was primarily on the basis of the confirmation of the hypothesis of Rokeach, that the rigid thinking characteristic of the ethnocentric individual is also characteristic of his approach to non-social problems, that led to the hypothesis formulated by the present writer.[63] Upon further study of the literature there was found additional observations that strengthened these hypotheses. The book, The Authoritarian Personality, by Adorno,

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[63] See Section in Chapter I, "The Problem and the Procedure."

Frenkel-Brunswik, Levinson, Sanford[64] proved to be a highly valuable source of information. In the chapter on "Personality Organizations Seen Through Interviews," written by Frenkel-Brunswik, the following observation is made:

> . . . there is in the records of the low scorers a tendency to use a great deal of qualifying phrases and other devices characteristic of an approach that is judicious rather than prejudicious through dogma, convention or a fixed set. . . . There seems to be a general tendency on the part of the low scorers to expose themselves to broad experience—emotional, cognitive, perceptual—even at the risk of having to modify one's preconceived notion and of having to sustain conflicts. Thus all evidence seems to point toward a greater over-all rigidity in the high scorers.[65]

Frenkel-Brunswik continues with:

> The inability to "question" matters and the need for definite dogmatic answers, as frequently found in high scorers, leads either to an easy acceptance of stereotyped, pseudoscientific answers, of which escape into ready-made hereditarian explanations is but one manifestation, or else to an explicitly antiscientific attitude. . . . Its opposite is a scientific-naturalistic attitude, found predominantly in the low scorers. . . . The antiscientific thinking of the typical high scorer is closely connected with his tendency toward superstition. . . . The fact that high scorers on ethnocentrism are more often given to stereotyping, pre-judgments and ready generalizations, or else to overconcreteness, should not blind us to the fact that there are also tendencies of this kind in low scorers.[66]

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[64] T. W. Adorne, and others, The Authoritarian Personality (New York: Harper and Brothers, 1950), pp. 990.

[65] Ibid., p. 464.

[66] Loc. cit.

And finally:

> . . . point toward the relative prominence in ethnically prejudiced as compared with unprejudiced children of a tendency to impose, in a rigid manner certain preconceived sets upon ambiguous perceptual data or upon the solving of reasoning problems.[67]

Cattell and Tiner[68] state that the concept of rigidity has been used widely in psychology dealing with personality. It has also been used as a possible explanation, "with positively journalistic abandon and inconsequence"[69] by the psychiatrists. "It should have been used," they say, "by the psychologists interested in learning theory, but with negligible exceptions it has not received any systematic examination in that direction."[70]

Cattell and Tiner use the term "rigidity" to mean "stiffness i.e., a resistance to forces attempting to produce change."[71] They have categorized rigidity into two classes: (1) the rigidity of processes—the tendency of an activity to persist when once activated;

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[67] Loc. cit.

[68] R. B. Cattell and L. G. Tiner, "The Varieties of Structural Rigidity," Journal of Personality, 17:321, March, 1949.

[69] Loc. cit.

[70] Loc. cit.

[71] Ibid., pp. 322-323.

and (2) structural rigidity—resistance of a habit or personality trait to forces which might be expected to change it, that is, to cause learning. Their paper is concerned with structural rigidity. They state that structural rigidity may arise from three classes of causes: (1) rigidity through failure of a new behavior to appear; (2) rigidity through internal dynamic conflict and equilibrium; and (3) Rigidity as a basic attribute of all dispositions. This latter may be another way of referring to generalized mental rigidity, for mention is made of "Other conceivable varieties of this inherent rigidity are rigidity of ergic (innately preferred) patterns as contrasted with acquired, actual habits; . . ."[72]

Frenkel-Brunswik,[73] in a paper dealing with perception and personality, states that a prime concern of her work is to bring together a variety of aspects to study the generality or lack of generality of the personality patterns involved. That is, she states, the readiness to spread from one area of manifestation to another. She asks the question: Can basic formal attitudes such

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[72] Ibid.

[73] E. Frenkel-Brunswik, "Intolerance of Ambiguity as an Emotional and Perceptual Personality Variable," Journal of Personality, 18:108-143, September, 1949.

as subjectivity, rigidity, fear of ambivalence and of ambiguity be taken as unified traits of the organism, or are we to find a more differential distribution, varying from one area to another? It is interesting to note that in this paper mention is made of the work of Rokeach[74] in that Frenkel-Brunswik worked with the same children that he employed in part of his work. She found that the rigidity scores derived by the arithmetic technique tend to correlate with over-all clinical ratings of children's rigidity based on their attitudes toward parents, sex-roles, self, moral values, etc., as revealed in clinical interviews. The evidence presented strongly suggests the generality of personality rigidity.

In a series of two papers by Cattell[75] on the subject of perseveration he came to the conclusion that disposition rigidity can be measured as a single general factor in batteries of tests covering a wide variety of motor performances. This factor of disposition rigidity, he states, at present best defined by motor tests, is definitely present also in some sensory, perceptual, and

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[74] Rokeach, op. cit., 259-278.

[75] R. Cattell, "The Riddle of Perseveration, I & II," Journal of Personality, 14:229-267, June, 1946.

symbolic processes. Avoidance of confusion with perseveration, he continues, requires that the term "disposition rigidity" be preserved precisely for the general factor now known.

To conclude this portion of the review of the literature a review of two papers consisting of a critique of the work of Rokeach by Luchins[76] and a rejoinder to the critique by Rokeach[77] is presented. It is felt that a presentation of these papers would clarify some of the points that might be considered debatable in the work of Rokeach (and of the work in this present report which stems from the research of Rokeach). It is also considered desirable to present a point of view opposed to the idea of generalized mental rigidity--the viewpoint of Luchins.

Luchins holds that the work of Rokeach was invalid on the following points: (1) the study did not confirm the hypothesis and that it contained a number of methodological flaws; (2) that there was a possible lack of validity and reliability of the measuring devices that were used to measure ethnocentrism, rigidity, and

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[76] A. S. Luchins, "Rigidity and Ethnocentrism: A Critique," Journal of Personality, 17:449-466, June, 1949.

[77] M. Rokeach, "Rigidity and Ethnocentrism: A Rejoinder," Journal of Personality, 17:467-474, June, 1949.

concrete-minded responses; (3) the interpretation of the results in terms of responses being indicative of or due to something in the subject's personality and that this something was in the nature of a general factor; (4) that the study disregarded the possibility of the results stemming from the field conditions; and (5) that the investigation follows the class-oriented psychological approach rather than the field-theoretical approach.

Luchins[78] suggests that the responses on the California Ethnocentric Scale are not reliable due to the fact that relatively few items are utilized in the make-up of the scale. He also indicates that there is the possibility that the verbalized responses by the subjects to the items are not truthful, or may have been misinterpreted by the subjects, or that the responses were due to conditions that existed at the moment and were peculiar to that particular moment. Luchins further suggests that Rokeach arbitrarily cut the experimental groups of subjects into rigid and nonrigid categories using the median as a convenient point of demarcation. He contends that this arbitrary method could be characterized on the basis of the utilization of absolute values.

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[78] Luchins, op. cit., pp. 448-449.

In reply to this portion of the critique Rokeach[79] states that the reliability of the California Ethnocentric Scale is not zero, but ranges from 0.7-0.9. Therefore, he concludes, the responses are not "accidental." He further states that while there is controversy over the validity of prejudice scales based on verbalized responses

> . . . we preferred to get on with the research with the assurance that to the extent that responses to prejudice scales are hypothesized and found significantly related to other variables (e.g., rigidity and concreteness), to that extent at the least we may assume the scale to be both reliable and valid.[80]

In relation to the critique of the arbitrary dichotomization of the subjects into "High" and "Low" prejudice groups, Rokeach maintains that dichotomization does not necessarily impute the absolutes of complete prejudice or complete non-prejudice. He points out that throughout his paper such phrases as "ethnocentric person and variants thereof," and, "high in ethnocentrism and variants thereof" appeared frequently, thus belying the idea of an absolute conception.

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[79] Rokeach, op. cit., p. 468.

[80] Rokeach, op. cit., p. 467.

Luchins, in referring to Rokeach's main hypothesis, "The rigidity inherent in the ethnocentric persons' solution of social problems . . ."[81] asks the question as to why was it inherent in his solution? Rokeach replies that this a premise—and that the hypotheses presented are based on premises. He states, "It remains to be seen, of course, to what extent our basic assumption is confirmed. One way to determine this is by examining the outcome of . . . research."[82]

Luchins felt that the use of the arithmetic problems to determine rigidity is not valid. He contends that this is not a completely non-social situation and that emotional and social factors biased the results. Rokeach indicates that he admits that such a thing as a purely non-social problem does not exist. He feels that the arithmetic technique provides as non-social a device as could be found.

Rokeach defined rigidity "as the inability to change one's set when the objective conditions demand it, as the inability to restructure a field in which there are alternative solutions to a

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[81] Rokeach, op. cit., p. 259.

[82] Rokeach, op. cit., p. 468.

problem in order to solve that problem more efficiently."[83] Luchins contended that the experimental conditions did not meet the needs of this definition of rigidity. He asserted that the experimental set-up did not show that the objective conditions demanded that the subject change his set and that, therefore, the complicated solution was just as simple as the uninvolved solution. Rokeach's reply was to the effect that if the complicated solution was just as efficient then one would expect the subjects to continue to use it all through the experiment. But, on the contrary, there is shown during the progress of the experiment a progressive decrease in intricate solutions on successive problems.

Luchins takes the stand "that rigidity is not a function of the personality per se but of particular field conditions."[84] On the other hand, as Rokeach points out, Luchins seemingly contradicts himself for he speaks of the differences between feebleminded and normal children in terms of differences attributable to differences in the rigidity of personality structure.

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[83] Rokeach, op. cit., p. 260.

[84] Luchins, op. cit., p. 459.

Luchins bases his critique of the methodology used in the research on the grounds that Rokeach had used a class approach rather than a field approach in his procedure. He defined the class oriented method as: (1) based upon dichotomous classification in place of continuous grading; (2) categorization that is based upon end results rather than upon the nature of the processes involved in bringing about the end products; (3) concern is with statistical averages rather than with any particular case; (4) lack of concern with the exception to the rule; (5) ". . . consists in regarding an individual's behavior as determined by something in the individual's nature."[85]

Rokeach in reply to the charge of using the class oriented approach states that both personality and environmental factors are determiners of behavior, he chose to emphasize the factors of the personality. He further states that:

> Luchins seems to hold the view, not shared by the writer, that since field conditions determine the behavior it follows that only specific factors are operative, i.e., there are no constants in behavior. If Luchins' view were correct, generalizations would be possible only between one situation and another precisely like it. Our conception of psychological fields leaves room for the operation of both constant and variable factors. The situations we set up represented different

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[85] Luchins, op. cit., p. 465.

> psychological fields for different individuals. We tested the hypothesis that the variance of psychological fields between groups was greater than the variance of psychological fields within groups.[86]

And in relation to field theory, Rokeach states that:

> Luchins, furthermore, seems to hold the view that field theory is concerned only or primarily with different psychological processes underlying the same end product. Field theory is also concerned with the possibility that different phenotypes are expressions of similar genotypes. It is with the latter that our investigation was primarily concerned. Within a dynamic personality framework we set up hypotheses that different phenotypes (prejudice, rigidity in solving problems . . .) may be manifestations of a similar genotype. Our results, we feel, confirmed these hypotheses, and it is now necessary to specify more fully, by further research, the nature of this genotype.[87]

To summarize the findings in the literature it may be said that there is evident among the workers interested in the concept of rigidity two prevailing ideas: (1) rigidity as a general personality factor; and (2) rigidity as a specific factor which is manifested under a particular set of circumstances and for a specific action. The bulk of the evidence seems to point toward the concept of a generalized rigidity. The question is, however, still open for further research. There is evidently a considerable need for an

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[86] Rokeach, op. cit., p. 472.

[87] Rokeach, op. cit., p. 473.

understanding of: (1) the mental processes taking place when rigidity is manifested in problem solving situations; (2) a need for understanding the motor neurological processes involved in motor acts; and (3) a need for measuring instruments to detect, qualitatively and quantitatively, both rigid mental processes and rigid actions.

The concept of rigidity and the scientific method. In recent years the teaching of the scientific method in science courses has attained the status of an educational tenet.[88, 89, 90] In the Department of Biological Science of Michigan State College where this investigation was conducted, "to teach the student to think scientifically,"[91] has become a major educational objective. There

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[88] Committee on the Function of Science in General Education, Science in General Education (New York: D. Appleton-Century Company, 1938), pp. 100-102.

[89] V. L. Crowell, "The Scientific Method: Attitude and Skills Essential to the Scientific Method, and Their Treatment in General Science and Elementary Biology Textbooks," School Science and Mathematics, 37:525-531, May, 1937.

[90] Harvard Committee, General Education in a Free Society (Cambridge: Harvard University Press, 1945), p. 221.

[91] C. A. Lawson, "Basic Biological Science at Michigan State College, The Journal of General Education, 2:97, October, 1947.

are many and varied definitions of what is meant by the scientific method and it is easiest, perhaps, to think of scientific method in terms of the abilities that are implied in its use. An enumeration and discussion of these abilities is found in Chapter III. For the purposes of this discussion Cohen and Nagle present the view that:

> Scientific method is . . . the persistent application of logic as the common feature of all reasoned knowledge. From this point of view scientific method is simply the way in which we test impressions, opinions, or surmises by examining the best available evidence for and against them. . . . in essence scientific method is simply the pursuit of truth as determined by logical considerations.[92]

There are other methods of arriving at truth. The method of tenacity is one in which habit and inertia makes it easier for individuals to continue to believe a proposition simply because it has always been believed. This carries with it the closing of the mind to all contradictory evidence. A second method, the method of authority, is one in which appeal for answers to questions is made to some highly respected source. This method is a simple and inflexible holding to authority. It breaks down when differing

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[92] M. Cohen and E. Nagle, An Introduction to Logic and Scientific Method (New York: Harcourt, Brace and Company, 1934), pp. 192-193.

authorities appear. A third method sometimes used is the method of intuition, or the appeal to "self-evident" propositions. Examples of propositions believed in the past or at the present to be self-evident are: the orbits of planets are circular, the whole is greater than any of its parts, the earth is flat, bigamy is a sin. Many "self-evident" propositions have been and are being proved false upon testing. These three methods are all inflexible. None of them can admit the leading into error. None of these methods has any provision for correcting its own results. The scientific method differs in that it is a technique which enables the discovering and the testing of possible alternatives to propositions. The scientific method is flexible.

The concept of rigidity has been shown to manifest itself by a rigidity, an inflexibility, a stereotypy of thinking. This pattern of thinking is contrary to the mode of thinking utilized in the use of the scientific method. The work of Frenkel-Brunswik,[93] as reported above, shows that she finds that this may be true in that she apparently detects a relationship in the factors of ethnocentrism, rigidity of the thinking process, and scientific thinking.

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[93] T. W. Adorne, and others, op. cit., pp. 448, 464-465.

The work of Rokeach[94] also points out that rigidity of thinking is not confined to social situations alone, but rigid thinkers show an inflexibility of solution to other types of problems. The above indicates the possibility that individuals who are rigid in their patterns of thinking will not be able to utilize the scientific method in that both are incompatible, as the scientific method is a process of flexibility whereas rigid thinking is a manifestation of inflexibility.

Comprehensiveness

As discussed previously, not only is the scientific method valuable in its flexibility, but it is also a technique which allows for the discovering of possible alternatives to propositions. Upon the discovery of alternatives to propositions some choice has to be made amongst them. Here value judgments are utilized. Comprehensiveness is held as one of the more important of the scientific values along with such other requirements of constructs as fertility, multiple connections, causality, simplicity, generality of

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[94] Rokeach, op. cit., pp. 259-278.

application, and economy of thought.[95] Together these give the scientist a framework for evaluation and of choice among alternative hypotheses or propositions.

When faced with having to make choice among two or more alternative propositions, that one which is more comprehensive is the better. Einstein makes the following statement concerning comprehensiveness:

> The aim of science is, on the one hand, a comprehension, as complete as possible, of the connection between the sense experiences in their totality, and, on the other hand, the accomplishmehs of this aim by the use of a minimum of primary concepts and relations.[96]

Northrop states essentially the same idea when he writes:

> Clearly, that philosophy of culture is the more scientifically correct and adequate one which can take care of the widest range of facts concerning nature and the natural man. Just as Einstein's theory of mechanics is generally regarded as a more scientific and correct theory than Newton's because it takes care of all the facts for which Newton's theory cannot account. . . .[97]

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[95] H. Margenau, "Western Culture, Scientific Method and the Problem of Ethics," American Journal of Physics, 15:218-228, May, 1947.

[96] A. Einstein, Out of My Later Years (New York: Philosophical Library, 1950), p. 63.

[97] F. S. C. Northrop, The Logic of the Sciences (New York: Macmillan, 1946), p. 340.

In this study the interest is not in making choice based upon the relative comprehensiveness of alternative propositions, but upon the particular psychological implications concerning persons who are able to make the choice as to the more comprehensive of the two or more alternatives being dealt with. This study proposes to deal with the comprehensiveness of individuals. Rokeach, who has proposed the idea of this transposition from comprehensive propositions to comprehensive individuals, states:

> When one says, therefore, that one theory is more comprehensive than another there is the added psychological implication that persons embracing the more comprehensive theory will be more comprehending of phenomena falling within the subject matter of this theory than other persons embracing the alternative but less comprehensive theory.[98]

Rigidity of the thinking process, as heretofore discussed, indicates an inflexibility, a stereotypy of thought patterns. On the other hand, the comprehensiveness of an individual indicates the ability to comprehend many things, to have a wide scope of thought, to have the ability to see broad and general relationships. Here again, as in rigidity and scientific method, the two, rigidity

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[98] M. Rokeach, "Toward the Scientific Evaluation of Social Attitudes and Idealogies," The Journal of Psychology, 31, p. 99, January, 1951.

and comprehensiveness, are incompatible. It would seem that relatively non-rigid individuals would be more comprehensive in their patterns of thought. This is one of the propositions with which this study deals.

There is in the literature a number of papers that sustain the idea of comprehensive cognitive structures, and the converse of the narrow-minded cognitive structure. Rokeach[99] in a paper dealing with a method for studying individual differences in narrow-mindedness, used a technique that was adapted in the present paper in Chapter IV. Subjects were asked to describe in what way a group of concepts (previously determined to be related) were interrelated. He concluded that the descriptions could be ordered along a continuum ranging from a comprehensive to an isolated to a narrow organization. Rokeach defined a comprehensive organization as, ". . . one in which all ten concepts are organized into a single whole. . . ." The isolated organization is one in which the concepts are sub-structured into two or more divisions, but all concepts are included in the organization. The

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[99] M. Rokeach, A Method for Studying Individual Differences in "Narrow-Mindedness," Journal of Personality (In Press).

narrow organization is one in which one or more of the concepts are omitted from the subject's organization.

A second paper, stemming from first one above, by Rokeach,[100] dealt with narrow-mindedness and personality structure. An examination and analysis of the first paper results showed the existence of great differences in the organizational pattern of the concepts utilized. It was apparent that here was a means of examining the cognitive structure of the narrow-minded subjects as revealed by their cognitive organizations of the above concepts. It was seen that it was possible to study the organization of the parts entering into the whole—that is, the organization of the definitions of the concepts which made up the study. The research was concerned with two major problems: (1) are the differences exhibited by the subjects in the organization of total structures a function of or related to individuals in the organization of sub-structures; and (2) are the individual differences exhibited in the organization of both parts and wholes a function of or related to other personality factors? Rokeach concluded from his results that:

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[100] M. Rokeach, "Narrow-Mindedness and Personality," Journal of Personality (In Press).

> Subjects scoring high, middle and low in ethnocentrism organize significant segments of their social world in a successfully more comprehensive manner. Furthermore . . . those scoring at the low extreme also organize the parts entering into the whole in a relatively more abstract manner than those scoring middle or high in ethnocentrism. Finally, while individual differences in the organization of the total structure do not seem to be related to individual differences in the organization of the more peripheral political-economic sub-structure, they are found to be significantly related to individual differences in the organization of the more central religious sub-structures.
>
> . . . While persons scoring at opposite extremes in ethnocentrism may perhaps be equally resistant to change, this resistance may be conceived as a function of differences in underlying cognitive structures, Low scorers more frequently organize their social world comprehensively and abstractly and this is why their socila attitudes are resistant to change. They also organize non-social aspects of their world more comprehensively and abstractly. . . .[101]

Rokeach found that the converse of the above is also true: that the group of individuals high in ethnocentrism are resistant to change due to the fact that they organize their social world more narrowly and concretely than those low in ethnocentrism.

These two papers indicate that it is possible to study the cognitive structure of individuals with a relative degree of ease by the use of the techniques here suggested.

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[101] Loc. cit.

The Problem and the Procedure

The problem. A perusal of the foregoing materials indicated that there were several major problems that could be stated in the form of hypotheses to be tested. This report consists of the testing of the following hypotheses which are based upon the factual information and rationale that has been presented. The hypotheses tested are: (1) those individuals who manifest a rigidity in the thinking process will react differently to the various factors concerned with the scientific method; (2) groups of individuals relatively less rigid in their thinking processes will exhibit a pattern of thinking that is more comprehensive than a group whose thought processes are more rigid and, consequently, whose pattern of thinking is more isolated and narrower; and (3) the rigid personality structure and the comprehensive cognitive pattern will be found operative in a normal classroom situation which requires the use of the elements of the scientific method for the solution of a problem.

The general plan of procedure. The general plan of procedure followed in the testing of the three major hypotheses involved the following steps. The first step consisted of utilizing

the arithmetic technique[102] in order to establish two groups of subjects: one group designated as relatively rigid in the thinking process, and the other group categorized as relatively non-rigid in its patterns of thought. A second step consisted of designating subjects as "lows" and "highs" on the basis of scores obtained on the California Ethnocentric Scale.[103] A third grouping was obtained by administering to the subjects an interrelationships scale[104] designed to determine those subjects who were comprehensive, isolated, or narrow in their cognitive patterns.

As much of the work of this report stems from the findings obtained by Rokeach[105] it was decided to determine, independently, to what extent this work is valid. Therefore, subjects scoring high and subjects scoring low on the California Ethnocentric Scale were first compared as to their rigidity and non-rigidity of solutions in the arithmetic technique.

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[102] See Chapter II.

[103] See Chapter II.

[104] See Chapter IV.

[105] M. Rokeach,"Generalized Mental Rigidity As A Factor in Ethnocentrism," The Journal of Abnormal and Social Psychology, 43:259-218, July, 1948.

The first hypothesis was tested by comparing the performance of groups specified as rigid and non-rigid on a test containing items concerning the elements of the scientific method. The groups designated as "lows" and "highs" on the California Ethnocentric Scale were also compared on this basis. The second hypothesis was tested by comparing rigid and non-rigid groups as to the number of comprehensive, isolated, and narrow cognitive organizations exhibited by each. The highs and lows on ethnocentrism were also compared on this basis. As the work developed the following minor hypothesis was formulated and tested: a group of individuals who are more comprehensive in their thought processes will do better in the solving of scientific method test items than a group of individuals who are non-comprehensive in their cognitive structure. This was tested by comparing the means of the scores on the scientific method test items between subjects with a comprehensive structure and isolated structures; between subjects with comprehensive and narrow structures; and between subjects with isolated and narrow structures. The third major hypothesis was tested by comparing the performance of rigid and non-rigid groups; groups high and low on the ethnocentric scale; and comprehensive

and non-comprehensive groups on an experimental laboratory study in a normal classroom situation.

The statistical analysis of the data obtained from the preceding comparisons was based upon the testing of the null hypothesis. The results of analyses which show a significance level of above 5% were arbitrarily considered to be a rejection of the null hypothesis, and that the difference obtained cannot be fully explained by sampling fluctuations. Significance levels between the 20% level and the 5% level, while not large enough to completely reject the null hypothesis, were retained on the assumption that at these levels there is at least a possible trend towards a suitable level of rejection.

CHAPTER II

MEASUREMENT OF RIGIDITY BY THE ARITHMETICAL TECHNIQUE; MEASUREMENT OF ETHNOCENTRISM; GENERAL RIGIDITY

This chapter is devoted to a description of the subjects employed in the study, and of the basic measuring techniques utilized throughout the problem. The technique utilizing arithmetic problems as a measure of rigidity, and of ethnocentrism as a manifestation of rigidity is described. As the work accomplished by Rokeach,[1] in which he concluded that the rigidity inherent in the ethnocentric person's solution of social problems is not an isolated or independent phenomenon, but may be considered as an aspect of a general rigidity factor, is the basis from which this study stems, it is deemed necessary and desirable that this work of Rokeach be repeated. The concept of a general rigidity factor is also discussed.

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[1] M. Rokeach, "Generalized Mental Rigidity As A Factor In Ethnocentrism," The Journal of Abnormal And Social Psychology, 43:259-278, July, 1948.

The Subjects

As part of this study is concerned with a repetition and an independent study of the results obtained by Rokeach[2] it is not only necessary to repeat the techniques utilized by him, but also to have the subjects chosen on the same basis. Thus, the following description of the subjects employed follows that utilized by Rokeach[3] in his work.

The subjects utilized in all phases of this report were for the most part freshman students enrolled in the second term of the Basic Biological Science sequence at Michigan State College. They had all taken and passed the work of the first term of the sequence. In order to obtain more valid responses to the California Ethnocentric Scale those subjects belonging to minority groups were eliminated from consideration in the experimental procedures. The information utilized as a basis for selection or rejection of the subjects was gained from the data given by the subjects on the first page of the California Ethnocentric Scale.[4] Of the total group of

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[2] Loc. cit.

[3] Loc. cit.

[4] See Appendix A.

subjects employed in the various phases of this report, 70.38% were men and 29.62% were women. The average age of the subjects was 21.25 years.

The Arithmetic Technique As A Measure of Rigidity

Procedure. As this study is based upon the results obtained by Rokeach[5] it is necessary that the procedures utilized by him in the measurement of rigidity be duplicated as exactly as possible. Only in this way can results be compared. Therefore, in order to facilitate comparison of results and to standardize the procedure as much as possible, the following description of the measurement of rigidity by the arithmetical technique is as essentially given by Rokeach.

The fundamental plan of the arithmetic technique is to establish a set of conditions that would indicate, operationally, mental rigidity. Rigidity was defined by Rokeach "as the inability to change one's set when the objective conditions demand it, as the inability to restructure a field in which there are alternative solutions to a problem in order to solve the problem more

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[5] Rokeach, op. cit., pp. 259-278.

efficiently."[6] In order to meet the conditions imposed by this definition so that rigidity could be measured operationally in a non-social situation a variation of the Luchins' technique for the study of the Einstellung-effect was utilized.[7] The problems presented for solution involved the measurement of a designated volume of water through the manipulation of three jars of known capacities. Problems solvable by one complicated method were presented for solution in order to establish a mental set. These were followed by a number of problems, called critical problems, which are similar in appearance but solvable by a previously employed and simpler method. An example of the complicated type of problem in which there is only the complicated method of solution is presented in Figure 3.

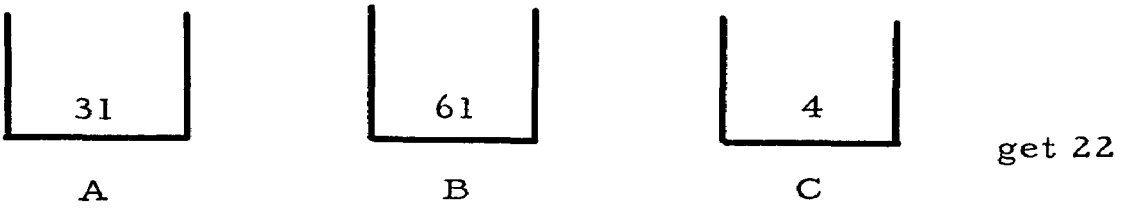

FIGURE 3

EXAMPLE OF A PROBLEM WITH ONLY ONE RIGID METHOD OF SOLUTION

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[6] Rokeach, op. cit., p. 262.

[7] A. S. Luchens, "Mechanization In Problem Solving," Psychological Monographs, 59, 1-95, 1942.

The problem is to obtain 22 quarts of water using these jars. The only correct solution is to fill the 61 quart jar, from this to fill the 31 quart jar and the 4 quart jar twice. There then remains in the 61 quart jar the required 22 quarts of water. If the first, second, and third jars are called A, B, and C, respectively, the method of solution would be B-A-2C.

The above set problems are followed by several critical problems, solvable by a simple method as well as by the rigid method. For example: the three jars have capacities of 23 quarts, 49 quarts, and 3 quarts, respectively (as shown in Figure 4), and the quantity of water required is 20 quarts. In this example, the rigid method of solution is 49-23-3-3 = 20. A subject who gives the B-A-2C solution to a critical problem[8] in which a simpler solution is possible, may be said to be solving such a problem in a rigid manner.

Instructions. In the experiment each problem was written on the blackboard in the form shown in Figures 3 and 4 (although the containers were not labeled). In the experiment there was a two minute time limit for each problem. The students were seated

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[8] It is to be admitted that there may be other, more complicated, methods of solution.

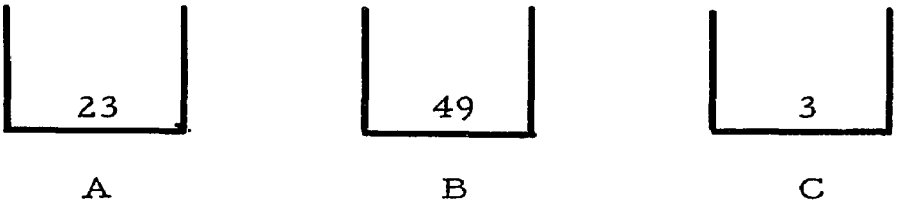

FIGURE 4

EXAMPLE OF A PROBLEM WITH BOTH A RIGID AND SIMPLE METHOD OF SOLUTION

in alternate seats. Each student had in his possession a booklet for his use. The booklet contained blank sheets of paper. The problems were written upon the blackboard so that the experimental situation was more controlled by the experimenter in that the subject could not work the problems except as they were presented upon the blackboard. The use of the blank booklet also allowed more control over the time situation as the problems were written upon the blackboard at two minute intervals only. The following instructions were given orally:

"This experiment is designed to see how well you can work simple problems without making mistakes. Your performance on this experiment will in no way affect your grade in this course.

"Imagine that you are standing beside a lake which has lots of water. In the first problem you are given three

empty jars. The first empty jar has a capacity of 13 quarts of water. The second empty jar has a capacity of 29 quarts of water. The third empty jar has a capacity of 3 quarts of water. Write down in your own words on the first right hand page of your booklet how you would go about getting exactly 10 quarts of water. Do the problem in the easiest possible way. You do not have to use all of the three jars in order to solve the problem."

The experimenter then allowed two minutes for the working of the problem. At the expiration of the two minutes, problem two was presented.[9] The experimenter then continued with:

"I will now explain how to do this problem (problem 2). The correct solution is to fill the 37 quart jar and from this to fill the 17 quart jar once and the 6 quart jar twice. There then remains in the 37 quart jar the required 8 quarts of water.

"Here is another way the solution of this problem may be written: 37-17-6-6=8.[10]

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[9] See Table I for problems.

[10] This problem is solvable only by the complicated method.

TABLE I

DESIGN OF PROBLEMS USED IN DETERMINING RIGIDITY

Problem Number				The Problem	Type of Problem
1.	13	29	3	get 10	Control critical problem
2.	17	37	6	get 8	Example
3.	31	61	4	get 22	Set Problems
4.	10	39	4	get 21	
5.	51	102	3	get 46	
6.	23	49	3	get 20	Critical Problems
7.	11	25	3	get 8	
8.	12	29	5	get 7	
9.	10	23	3	get 7	
10.	11	27	5	get 6	
11.	20	47	7	get 13	
12.	12	32	8	get 4	
13.	13	36	10	get 3	
14.	17	40	6	get 11	
15.	13	29	3	get 10	

"Each problem which I give you is to be worked on a new right hand page of your booklet. You will be allowed exactly 2 minutes to solve each problem. You are not allowed to turn any of the pages in your booklet except when I tell you to. Also, you are not allowed to go back to any previous problem on a previous page to change your answer or to fill in an omitted answer.

"Turn over to the next right hand page. You may use the left hand side of your booklet for figuring and scratch work. Here is the next problem, Problem 3."

Basic assumptions. Before being justified in saying that we have two groups, highs and lows, that can be compared on the basis of rigidity it is important that there is some assurance that both groups were measured in an equal manner and that the rigidity measured is in fact the defined rigidity. Therefore, a rigorous examination of a number of assumptions on which the measurement of rigidity is based is in order.

First, do the students comprehend the directions, and, secondly, is there a lack of arithmetical ability necessary to solve the problems presented. In either case, whether it be a comprehension or an arithmetical ability factor, it would manifest itself

in a failure to solve one or more problems. Therefore, those subjects who failed to solve any of these problems were eliminated from further consideration. Thus the remainder were equal to the extent that they were all found capable of solving the problems presented to them. A point to be brought forward is that the time given was adequate for the solution of the problems presented. The assumption was made that the two minute intervals between problems was sufficient. Here again equation was obtained in that the subjects' work was examined and where one or more problems were unfinished, that individual was discarded from consideration. There were only three individuals of the 253 subjects that were so found. There was a minimum of cheating due to the fact that it was stressed in the directions that this experiment would not affect the grade of the student, that there were also several proctors in the room and because they were seated in every other seat. The directions also stressed, and the proctors forewarned, that there was to be no turning back into the booklets and solving the foregoing problems. Specifically, then, the problem of deception was minimized.

A most important assumption will now be examined: that all subjects have the ability to solve the problems in the simple,

non-rigid way when the problem is actually solvable by both methods—and will actually solve the problem in a simple way when there is no set established. There must be some assurance that a rigid solution is due to an experimentally established mental set and that the problems would not, ordinarily, be solved rigidly unless preceded by set problems. This is accomplished by use of the control critical problem. Those individuals who solve the control critical problem by the simple, non-rigid method are retained for the experiment, those who use the complicated, rigid manner in solving the control critical problem are eliminated. There were some forty-nine eliminations on this basis. Therefore, by eliminating those subjects who solve the control critical problem in a rigid or complicated method, and by considering, in the statistical analysis, only those subjects who solve the control critical problem by the simple method, whatever differences in rigidity there may appear will have to be attributed to different strengths of a rigid Einstellung-effect experimentally induced. Thus, every subject retained in the analysis of the results demonstrated that he is able to solve the control critical problem non-rigidly.

A further assumption upon which this device rests is that there exists little or no relationship between the ability to solve

the arithmetic problems and intelligence; little or no relationship between the arithmetic ability and such other qualities as the American Council On Education Psychological Examination For College Freshmen and the Cooperative Test of Reading Comprehension measures.

There is evidence that the results obtained are not attributable to the operation of an arithmetical ability factor. First, as the paper by Rokeach[11] indicates, a study was made in which cases from the Child Guidance Study and the Growth Study at the Institute of Child Welfare, University of California, were used. The correlation between arithmetical rigidity scores and the arithmetic score on the Wechsler-Bellevue was +0.01. Secondly, the results obtained in this present study show that the correlation between the Q-score of the American Council On Education Psychological Examinations (this score purports to measure abilities involved in quantitative thinking) and the arithmetical rigidity gave an r of + 0.013 for the subjects of this report. These data indicate no correlation between rigidity as measured by the arithmetic technique and arithmetical ability as measured by the above mentioned instruments.

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[11] Rokeach, op. cit., p. 268.

This study is based upon the assumption that the results obtained are due to a general rigidity factor and not to a general intelligence factor. Rokeach[12] presents evidence gained from the Child Guidance and Growth Study cases to support this. The Pearson product-moment correlation, between rigidity as measured by the arithmetic technique and the Stanford-Binet IQ is -0.19; between rigidity and the Wechsler-Bellevue IQ is -0.13. Additional information obtained from the present study corroborates these findings. The correlation between the T-score of the American Council On Education Psychological Examination, which is a measure of general college ability and rigidity, was found to be -0.028. Thus the assumption that there is no significant correlation between intelligence and rigidity as measured by the arithmetic technique appears to be borne out.

Other qualities measured by the American Council On Education Psychological Examinations and the Cooperative Test of Reading Comprehension and rigidity as measured by the arithmetical technique were correlated. The r of the L-score, measuring linguistic abilities, and rigidity was $+0.198$; between general

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[12] Loc. cit.

reading ability and rigidity was − 0.189. None of these differences is significant, indicating that in these qualities also there is little relationship, if any, to rigidity.

Results. A study of the results of this measurement of rigidity shows that the mean number of problems solved non-rigidly by the entire group of 253 subjects is 5.62 out of ten problems. The group was arbitrarily divided into two equal categories, rigid and non-rigid. This was determined by ascertaining whether the subject obtained a score falling above or below the median of all subjects participating in a given experiment. The mean number of problems solved non-rigidly by the rigid group of all the subjects was 1.41 problems, and the mean number of problems solved non-rigidly by the non-rigid group is 9.48. The total possible number of problems that could be solved non-rigidly was ten problems.

The Measurement of Ethnocentrism

Design of the scale. The California Ethnocentric Scale[13] of ten items was used to obtain a measure of the extent of the

[13] D. J. Levinson, "An Approach to the Theory And Measurement of Ethnocentric Ideology," The Journal of Psychology, 28:19-39, January, 1949.

subject's ethnocentrism. The scale is presented in Appendix A.

Instructions. The introduction, purpose of the scale, and the instructions for the use of the scale are part of the scale. These were read orally by the experimenter while the subject read the scale instructions to himself.

Basic assumptions. For a detailed discussion of the construction and characteristics of this scale the reader is referred to Levinson and Sanford[14] and Levinson.[15] However, as this scale is of importance to the study herein reported, a discussion of the basic assumptions upon which the use of the scale has been resolved follows.

Among other assumptions, those of reliability and validity of the scale are outstanding. The scale has shown a reliability by the split-halves method and by comparison to other scales and to sub-scales of the test itself to average an r of over + 0.8 and running as high as + 0.91. Measuring devices such as a scale

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[14] D. J. Levinson and R. Sanford, "A Scale for the Measurement of Anti-Semitism," Jour. of Psychology, 17:339-370, December, 1944.

[15] Levinson, op. cit., pp. 19-39.

measuring "implicit anti-democratic trends," i.e., ideas about self, family, personal relationships, and people generally gave an r of + 0.75 with the E-scale. The intercorrelations between the sub-scales of the test gave r's of + 0.90 to + 0.92. A high level of internal consistency of the scale is shown by use of the discriminating power (DP) of each item. Item DP's are obtained as follows: subjects making total ethnocentricism scores in the top 25% are considered highs, those in the bottom 25% as lows. For each scale item the mean score made by the low quartile is subtracted from the mean score of the high quartile and the difference is the DP. Thus, on an item in which the high quartile has a mean of 6.17 (agreeing + 2 on the average),[16] while the low quartile has a mean of 1.97 (disagreeing − 2 on the average)[17] the DP being 4.20. In general, DP's over 2 are satisfactory, while values approaching or surpassing 4.0 indicate almost no overlapping between the high and the low groups. The average DP of the E-scale has been shown to be 3.86,[18] again indicating

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[16] See page 68 for method of scoring.

[17] See page 68 for method of scoring.

[18] Levinson, op. cit., pp. 19-39.

a high level of internal consistency. The E-scale has been shown to have statistically significant relationships with political economic conservatism. This has also been shown through case study methods, intensive interview methods, and such tests as the Thematic Apperception Test and Projective Question Test.[19]

From the above it can be stated that the E-scale is reliable and valid. In general the controversy over the validity of prejudice tests is primarily on the ground that verbalized responses are not necessarily truthful. Rokeach, however, has very aptly stated that:

> While we agree with this, we prefer to get on with the research with the assurance that to the extent responses to prejudice scales are hypothesized and found significantly related to other variables (e.g., rigidity and concreteness), to that extent at the least we may assume the scale to be both reliable and valid.[20]

An important assumption on which this report is founded is that there is no sizable correlation between ethnocentrism and intelligence. The question can be raised, of course, as to the possible differences in intelligence between the high and low scorers

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[19] Loc. cit.

[20] M. Rokeach, "Rigidity and Ethnocentrism: A Rejoinder," Journal of Personality, 17:467, June, 1949.

in ethnocentrism which would account for the differences found. Murphy, Murphy and Newcomb[21] state that they found no correlation between intelligence (however tested) and degree of radicalism on Internationalism, the Negro and economic issues. Nine university groups were so tested. Horowitz[22] found no evidence for the existence of a relationship between intelligence and attitudes toward the Negro. However, a number of reports, including those of Zelige and Hendrickson[23] and Pinard[24] gave correlations of + 0.30 to + 0.35. In this study, by the use of the Pearson Product-Moment method, a correlation between the E-scale and the T-score of the American Council On Education Psychological Examinations of + 0.301 (significant above the 1% level) was found. There therefore seems to be some evidence of a relation between ethnocentrism and intelligence. That the correlation is small, in

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[21] G. Murphy, L. Murphy and T. Newcomb, Experimental Social Psychology (New York: Harpers, 1937), pp. 1121.

[22] E. Horowitz, "Race Attitudes," Characteristics of the American Negro (New York: Harper Brothers, 1944), p. 409.

[23] R. Zelige and G. Hendrickson, "Racial Attitudes of 200 Sixth Grade Children," Sociology and Social Research, 18:34, September, 1933-34.

[24] J. Pinard, "Tests of Perseveration," Brit. Jour. Psychology, 23:114-126, July, 1932.

the neighborhood of + 0.3, may be evidence, actually, that intelligence may be only one of many other variables which determine E-scale scores.

Results. In all of the experiments in which the E-scale scores were used the subjects were divided into two groups, those high in prejudice and those low in prejudice. As can be seen from the scale (Appendix A) the subjects were allowed six choices of response for each item, ranging from strong agreement to strong disagreement, with no neutral category. Since higher scores were intended to express increasing ethnocentrism, all responses were converted into scores in the following manner as suggested by Levinson:[25]

− 3	strong disagreement	1 point
− 2		2 points
− 1		3 points
+ 1		5 points
+ 2		6 points
+ 3	strong agreement	7 points

Whether a person was high or low was determined by whether he obtained a score above or below the median of all subjects participating in a given experiment. Of the entire group tested the

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[25] Levinson, op. cit., pp. 19-39.

median score was 33.20. The median score for the highs was 42.41, and the median score for the lows was 23.57.

General Rigidity, the E-Scale And Arithmetical Rigidity

Rokeach[26] hypothesized that the rigidity inherent in the ethnocentric person's solution to social problems is not an isolated or an independent phenomenon, but may be considered an aspect of a general mental rigidity factor which will manifest itself in the solution of any problem, be it social or non-social in nature. Rokeach confirmed this hypothesis by the use of the arithmetic and spatial techniques. Further confirmation of this hypothesis is shown by the statistical analysis of the E-scale and the measurement of arithmetical rigidity data gathered in the study here being reported.

The statistical analysis of the data gathered for the purpose of comparing those scoring high and those scoring low on the California Ethnocentric Scale in relation to rigidity and non-rigidity of solutions of arithmetic problems is presented in Table II.

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[26] M. Rokeach, "Generalized Mental Rigidity As A Factor in Ethnocentrism," The Jour. of Abnormal and Social Psychology, 43:259-278, July, 1948.

TABLE II

COMPARISON OF THOSE HIGH AND LOW ON ETHNOCENTRISM FOR RIGIDITY AND NON-RIGIDITY OF SOLUTIONS

Critical Problem	N Highs 73 Rigidity of Solutions				N Lows 73 Non-Rigidity of Solutions				X^2	Sig. Level
	Number		Percent		Number		Percent			
	Highs	Lows	Highs	Lows	Highs	Lows	Highs	Lows		
6	55	43	75.34	58.90	18	30	24.65	41.09	4.468	5%
7	45	33	61.64	45.70	28	40	38.35	54.79	3.962	5%
8	40	29	54.79	39.72	33	44	45.20	60.27	3.322	10%
9	37	25	50.68	34.24	36	48	49.31	65.75	4.004	5%
10	35	23	47.94	31.50	38	50	52.05	68.49	4.118	5%
11	35	21	47.94	28.76	38	52	52.05	71.23	5.660	2%
12	34	21	46.57	28.76	39	52	53.42	71.23	4.912	5%
13	33	20	45.20	27.39	40	53	54.79	72.60	4.996	5%
14	33	20	45.20	27.39	40	53	54.79	72.60	4.996	5%
15	33	17	45.20	23.28	40	56	54.79	76.71	7.780	1%
Total	380	252			350	478				
Total Possible	730	730			730	730				
% Total Possible	52.0	34.5			47.9	65.4				

A perusal of Table II will show that there is a significant difference in number of non-rigid solutions for all critical problems with the exception of problem eight. All other differences were significant at the 5% level or better. Problem eight was at the 10% level. It is also important to note that, and this includes problem eight, all numerical differences were in the hypothesized direction. There is also noticed a progressive increase in the number of non-rigid solutions to the critical problems. However, the low scorers show a greater number of non-rigid solutions throughout the experiment.

The above evidence supports the work of Rokeach.[27] Therefore, from the above evidence, as well as from the evidence reported by Rokeach, it would appear that groups of individuals high on ethnocentrism are also rigid as measured by the arithmetic technique. That this is a general rigidity, and not due to an arithmetical ability difference between the two groups, has already been discussed under the Basic Assumptions of the Measurement of Rigidity.

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[27] Loc. cit.

The subjects used in the following experiments, described in Chapters III, IV, and V, are drawn from the group of subjects utilized in this portion of the work. As will be seen upon further reading of this report, the various experimental groups will be numerically different. The reason for this was that in making the various comparisons it was found that all subjects did not participate in taking all of the measuring devices. This was usually due to absence from class. Therefore, as the comparisons on the basis of the various measuring were analyzed, only those individuals who had been measured on all of the devices being compared were used.

CHAPTER III

BEHAVIOR OF RIGID AND NON-RIGID GROUPS IN RELATION TO THE ELEMENTS OF THE SCIENTIFIC METHOD

In general it is hypothesized that those individuals who manifest a rigidity in the thinking process will react differently to the various factors concerned with the scientific method. This portion of the study deals with this general hypothesis in specific terms and the hypothesis can be more precisely stated as: Subjects exhibiting a relatively lower rigidity of the thinking process will score higher on test items judged as measuring the ability to comprehend the scientific method than subjects relatively greater in the rigidity of their thinking processes. The hypothesis is tested as follows.

Design of the study. There were selected thirty-three questions testing the ability of the subjects to comprehend the aspects of the scientific method as specifically concerned with problems in Biological Science. The study was conducted under the rigorous conditions accompanying an examination. Subjects were spaced as to seating, differing forms as to location of items were used, and proctors were scattered throughout the examination rooms.

The scientific method items themselves are found in Appendix B. The thirty-three items selected covered the eighteen aspects of the scientific method listed below:

1. Ability to recognize a logical hypothesis.
2. Ability to recognize the best hypothesis among two or more alternatives.
3. Ability to recognize a statement that is not an hypothesis.
4. Ability to recognize an illogical hypothesis because it contradicts the data.
5. Ability to recognize data contradicting an hypothesis.
6. Ability to recognize data supporting an hypothesis.
7. Ability to recognize data unrelated to the hypothesis.
8. Ability to recognize a principle.
9. Ability to recognize a valid experiment.
10. Ability to recognize the results of an experiment.
11. Ability to recognize the probability factor in an experiment.
12. Ability to recognize causal relationships.
13. Ability to recognize a statement warranted by all or part of the data given.
14. Ability to recognize a statement contradicted by the data.
15. Ability to recognize a reasonable interpretation of the data.

16. Ability to recognize data insufficient to warrant any conclusion.

17. Ability to recognize statements going beyond the inferences to be drawn.

18. Ability to recognize a statement contradicted in whole or part by inferences based on one or more experiments.

A discussion of these items is taken up in the section on the Basic Assumptions of this study.

Instructions. The only instructions given were those necessary to facilitate the performance of the study. The instructions for each item was an integral part of the test and so no instructions apart from this were given or were necessary for the performance desired.

Basic Assumptions. It is assumed that the elements of the scientific method selected are actually the necessary elements of the scientific method. A review of the literature on this subject appears to the writer to bear out this assumption. The elements utilized in this report have been explicitly chosen by the Department of Biological Science at Michigan State College as objectives to be taught and tested. Much work has gone into the program of the selecting, teaching, and testing of the factors of the scientific method. There is general and specific agreement

of the factors listed here with the factors listed by Burmester[1] in her work on the development of an objective examination to test as many phases of the scientific method as can be tested by objective tests. The work of such men in the field as Tyler,[2] Keesler,[3] Glaser,[4] and the Committee on the Function of Science in General Education,[5] Fruchtey and Tyler,[6] and Zyve[7] also show

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[1] M. A. Burmester, "A Synthesis and Evaluation of Objectives for Biological Science in the Basic College of Michigan State College." Unpublished Master's Thesis, Michigan State College, East Lansing, 1948, pp. 128.

[2] Ralph W. Tyler, Construction of Achievement Tests (Columbus, Ohio: Ohio State University, 1934), p. 4.

[3] O. Keeslar, "Elements of the Scientific Method," Science Education, 29:275-277, December, 1945.

[4] E. M. Glaser, An Experiment in the Development of Critical Thinking (New York: Bureau of Publications, Teachers College, Columbia University, 1941), pp. 5-6.

[5] Committee On The Function of Science in General Education, Science in General Education (New York: D. Appleton-Century Company, 1938), pp. 27-49.

[6] F. P. Fruchtey and R. W. Tyler, "Examination in the Natural Sciences," in The Construction and Use of Achievement Examinations, H. E. Hawkes and others, editors (Boston: Houghton Mifflin Co., 1936), pp. 214-263.

[7] D. L. Zyve, "A Test For Scientific Aptitude," Jour. of Educational Psychology, 18:529-530, November, 1927.

that the elements listed for the study being reported are the most frequently mentioned elements of the scientific method.

A second assumption concerns the reliability and validity of the items under consideration. They are considered reliable and valid on the basis of the following. The split halves method of determining reliability was used on the thirty-three items utilized. In determining the reliability the questions were first ranked in order of their degree of difficulty. Two half scores of each subject was obtained by utilizing the odd-even method. The coefficient of correlation of these was 0.952. For the estimated reliability of the entire test the Spearman-Brown formula was applied and found to be 0.975. This would indicate high reliability. The staff of the Department of Biological Science of Michigan State College has indicated that the items are valid as to the measurement of the elements of the scientific method as far as they can be measured by an objective multiple-choice test.[8]

An analysis of the items of the study shows that they utilize a good deal of subject matter in dealing with the factors of the scientific method. It may be argued that what is being measured,

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[8] It should be noted here that this test is not applicable as a general test in the scientific method except as it applies to students in Biological Science.

as far as the rigid and non-rigid groups are concerned, is a subject matter differential. This, indeed, is a serious concern of the study and of studies of a similar nature where there is an attempt to dissociate verbals from patterns of thinking. It may be recalled that there is little or no statistical difference between the two groups as concerns the various attributes measured by the American Council on Education Psychological Examinations for College Freshmen and the Cooperative Test of Reading Comprehension. These include such factors as quantitative thinking, linguistic abilities, general college ability, recognition vocabulary, rate and level of comprehension, and general reading ability. From this lack of significance it can be inferred that the two groups, rigid and non-rigid, have a similar body of factual information for, as far as can be told, they have had equal opportunity for the acquisition of this information with evidently similar abilities for understanding of this information.

Results. Table III presents a comparison of the behavior of the rigid and non-rigid groups, on the items presented in the section on the Design of the Study, testing the elements of the scientific method. An inspection of Table III will show that, in general, the difference between the rigid and non-rigid groups is in

TABLE III

COMPARISON OF RIGID AND NON-RIGID GROUPS ON ITEMS TESTING THE ELEMENTS OF THE SCIENTIFIC METHOD

Problem*	N Rigid 59 / N Non-Rigid 59 Number of Correct Solutions		Chi-Square	Significance Level
	Non-Rigid	Rigid		
1a	43	29	7.26	1%
1b	46	35	4.762	5%
1c	43	33	3.694	10%
1d	22	10	3.924	5%
2	43	32	4.424	5%
3a	25	14	4.62	5%
3b	23	12	4.84	5%
4	48	38	4.286	5%
5	17	9	3.165	10%
6	34	22	4.88	5%
7	35	24	4.08	5%
8a	25	13	5.58	2%
8b	27	16	5.00	5%
9	9	8	**	**
10	48	50	**	**
11a	23	14	3.188	10%
11b	37	24	5.64	2%
11c	28	17	3.99	5%
12a	35	24	4.08	5%
12b	42	32	3.622	10%
12c	35	21	6.66	1%
13	53	41	7.52	1%
14	35	35	**	**
15a	49	51	**	**
15b	35	37	**	**
15c	25	31	**	**
16a	47	35	5.74	2%
16b	45	42	**	**
16c	46	35	4.762	5%
17a	43	48	**	**
17b	43	45	**	**
18a	38	25	5.74	2%
18b	36	24	4.6	5%

* See Appendix B for the problems.
** Not significant.

the hypothesized direction. Four items were significant at the 10% level. On the basis of the standards previously set up while there is no rejection of the null hypothesis at this level, there is, however, the trend towards the rejection. Twenty of the items were significant at the 5% level or above: thirteen were at the 5% level, four at the 2% level, and three were at the 1% level. In these twenty items the null-hypothesis can be rejected. Only in nine of the thirty-three items was there no significant difference at all.

The above data suggest that in general there is agreement with the hypothesis that rigid and non-rigid groups will react differently to the elements of the scientific method—that the non-rigid group will be able to utilize the elements of the scientific method more efficiently than the rigid individuals. To support this hypothesis on the level of the total number of factors and items involved in the testing of these factors of the scientific method, the calculation of the standard error of the difference of the means was resorted to. The critical ratio was found to be 5.238. With the 1% level at 2.58 it is readily seen that a critical ratio of 5.238 on the entire test the null hypothesis can certainly

be rejected. Statistically the non-rigid group has done considerable better than the rigid group of individuals.

It is interesting to note from Table III that, in all but one case, where more than one item was used to test an element of the scientific method and one item was found to be not significant, all items were not significant for that particular factor.

As ethnocentrism may be considered a manifestation of rigidity of thinking it was considered necessary to study the performance of those high and of those low on ethnocentrism on this series of scientific method test items. Table IV presents a comparison of those high and of those low on ethnocentrism on items testing the elements of the scientific method. Upon inspection of Table IV it is found that of the thirty-three items used, eighteen were not significant at least at the 10% level. However, thirty-one out of the thirty-three items were in the hypothesized direction even though they were not all significantly so. There were fifteen items that were significant at less than the 10% level. Of these fifteen items five were at the 10% level, five at the 5% level, one at the 2% level, and fo r at the 1% level. Here, too, it is interesting to note that for the entire group of thirty-three items there is a highly significant difference between the two groups—and

TABLE IV

COMPARISON OF THOSE HIGH AND OF THOSE LOW ON ETHNOCENTRISM ON ITEMS TESTING ELEMENTS OF THE SCIENTIFIC METHOD

Problem*	N Rigid 89 Number of Correct Solutions		N Non-Rigid 89 Chi-Square	Significance Level
	Lows	Highs		
1a	78	56	14.60	1%
1b	72	49	13.64	1%
1c	57	50	**	**
1d	28	24	**	**
2	63	49	4.718	5%
3a	36	30	**	**
3b	28	22	**	**
4	71	60	3.498	10%
5	24	11	6.0102	2%
6	45	43	**	**
7	48	34	4.430	5%
8a	38	24	4.868	5%
8b	37	34	**	**
9	16	12	**	**
10	69	61	**	**
11a	36	29	**	**
11b	45	39	**	**
11c	33	41	**	**
12a	49	36	3.8054	10%
12b	58	45	3.8738	5%
12c	48	35	3.814	10%
13	79	57	15.080	1%
14	52	51	**	**
15a	75	74	**	**
15b	55	54	**	**
15c	40	37	**	**
16a	67	54	3.716	10%
16b	66	65	**	**
16c	65	53	3.62	10%
17a	67	57	**	**
17b	66	61	**	**
18a	45	32	3.866	5%
18b	49	30	8.20	1%

* See Appendix B for the problems.
** Not significant.

in the hypothesized direction. The critical ratio in this case is 4.617, which is far above the 2.58 necessary for significance at the 1% level. It can be stated, therefore, that on the test as a whole there is a rejection of the null hypothesis. It may be inferred that those high in ethnocentrism are not as capable of utilizing the methods of science as those low in ethnocentrism.

The results[9] reported in Table III again indicate that the factor of general rigidity is operating. Not only is the ability to utilize the elements of the scientific method a manifestation of a general rigidity factor, as shown by the results presented in Table III, but there is evidently a significant difference in the ability of the groups high and low in ethnocentrism to handle these elements. This is supporting evidence for the conclusions reached by Frenkel-Brunswik, "The ability to question matters and the need for definite dogmatic answers as frequently found in high scorers, leads either to an easy acceptance of stereotyped, pseudoscientific answers, of which escape into ready made hereditarian explanation is but one manifestation, or else to an explicitly unscientific attitude . . . Its opposite is a scientific naturalistic attitude,

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[9] The relationship between scientific method items and comprehensiveness is dealt with separately in Chapter IV.

found predominantly in low scorers. . . ."[10] She based these conclusions on the results of interviews with both high and low scorers in ethnocentrism. The results presented in this study lend a good deal of experimental and statistical evidence to the interview results found by Frenkel-Brunswik[11] and others.

The attempt was made to break down the scientific method test items into two groups: (1) a group of items related to the analytical aspects of the scientific method; and (2) a group of items related to the synthetic aspects of the scientific method. It was found that this was not a feasible breakdown for these items did not appear to be discriminative for synthesis and analysis from the viewpoint of scientific methodology.

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[10] T. W. Adorno, and others, The Authoritarian Personality (New York: Harper and Brothers, 1950), pp. 464-465.

[11] Loc. cit.

CHAPTER IV

BEHAVIOR OF RIGID AND NON-RIGID GROUPS IN RELATION TO COMPREHENSIVENESS

It was the aim of this portion of the problem to test the hypothesis of comprehensiveness as discussed in the first chapter. Briefly, the concept of comprehensiveness is held as one of the more important of the scientific values along with such other requirements of constructs as fertility, multiple connections, causality, simplicity, generality of application, and economy of thought.[1] Together these give the scientist a framework for scientific evaluation and of choice among alternative hypotheses. The hypothesis that was tested here is as follows: Groups of individuals relatively less rigid in their thinking processes will exhibit a pattern of thinking that is more comprehensive than a group whose thought processes are more rigid and, consequently, whose patterns of thinking more isolated and narrower.

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[1] H. Margenau, "Western Culture, Scientific Method, and the Problem of Ethics," American Journal of Physics, 15:218-228, May, 1947.

Design of the study. This study is derived from a technique employed by Rokeach[2] in testing for comprehensiveness on the level of religious and political and economic phenomena. A list of biological phenomena was prepared which contained the twelve following terms: adaptation, cell membrane, cellular respiration, cytoplasm, growth, metabolism, movement, nucleus, reproduction, mitosis, chromosomes, and genes. The list was pretested upon some 150 subjects, and on the basis of this pretesting the terms mitosis, chromosomes, and genes were dropped, as many of the subjects were evidently not familiar enough with these terms to be able to define and use them correctly. The remaining nine terms were used on another group of some 125 subjects. This time reaction to the list was favorable and so these terms were retained for use in the experiment. Figure 5 shows the worksheet that was given to the subjects. Ordinary classroom conditions prevailed in this study which was given during the regular laboratory periods.

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[2] Milton Rokeach, "Toward the Scientific Evaluation of Social Attitudes and Ideologies," The Journal of Psychology, 31: 97-104, January, 1951.

Name _____

Lab. Instructor _____

1. Adaptation

2. Cell membrane

3. Cellular respiration

4. Cytoplasm

5. Growth

6. Metabolism

7. Movement

8. Nucleus

9. Reproduction

Interrelations

FIGURE 5

WORKSHEET UTILIZED TO DETERMINE COMPREHENSIVE, ISOLATED AND NARROW COGNITIVE STRUCTURE

Instructions. The worksheets were passed out to the subjects and the following instructions were issued:

"On the paper before you are a number of terms used very frequently in Biological Science. I am interested in finding out whether student difficulty with these terms is due to the fact that different people do not mean the same thing when they use these terms. Would you please write down next to each term what you understand to be its meaning. Don't spend more than a minute or so on each term. You don't have to worry about being precise in your definitions. Just tell me as briefly as possible what you understand to be the general meaning of each of these terms. It is important that you define every term. Go ahead."

When the subjects had finished this portion of the work, the following was given to them:

"As you can probably see, the terms which you have defined refer to important biological phenomena. To some extent all of these are related to each other. Here is what I would like you to do next. Write a paragraph in the blank space provided at the bottom of your sheet in which you describe in what way all of these terms might be interrelated

with each other. Do not worry how well organized your paragraph is because it isn't important for purposes of this experiment. Just tell me in what way these terms are very much related to each other. If you do not think all of these terms are very much related to each other then just write about those terms which you think are related to each other and skip the rest. You have about five minutes to do this. Go ahead!"

These instructions, and only these instructions, were repeated if requested by the subjects.

Basic Assumptions. One of the primary assumptions upon which this portion of the study rests is that the subjects understand the terms used in the study. All of the terms used are an essential part of the work of the first course in Biological Science at Michigan State College which all of the subjects have taken. All of the subjects have passed a rigorous final examination, which to some extent contained the phenomena utilized in the experiment. Care and pretesting were used in the selection of these phenomena. Pretesting indicated general familiarity with these terms. Finally, an examination of the worksheet used in the experiment shows that the subjects defined the terms that were eventually incorporated into

the study. Worksheets showing lack of familiarity with the phenomena were eliminated. Though it should be emphatically stated that the work here is not concerned with the subjects' factual information, but most definitely with his organizational approach. The results tabulated from an inspection of worksheet were in terms of the mental organization suggested thereon.

It is also assumed that it is possible to incorporate all of the phenomena under one inclusive and comprehensive organization. This factor was also pretested upon biologists in the Department of Biological Science at Michigan State College and students in course in Biological Science. In both cases it was found that this was possible of attainment. Study of the results of the experiment, of course, also bear this out. Therefore, without even going into experimental results, it was known in advance that the phenomena are capable of being brought together and organized into a comprehensive whole.

Results. An intensive study of the statements made by the subjects relative to the interrelationships which might exist among the terms presented showed that these statements could be ordered along a continuum ranging from comprehensive organization

at one extreme through isolated organizations at the middle to narrow organizations at the opposite extreme.

A comprehensive organization is one in which all the biological phenomena under consideration are organized within a single unified structure. The thought processes here have undergone a synthesis, rather than an analysis, in which objects of thought have been made into a complex of the whole. The thought processes are broad and integrated and with all the phenomena in the description. The following are examples of this type of synthesis: "They are all necessary to maintain the life of the cell," "They are all common to all living things," "They are all means of distinguishing living matter as they are all characteristic of living cells," "These terms are related in that all together they make the whole," "All are necessary to carry on the processes of life," "All are necessary to maintain life in the cell and to maintain the species."

An isolated organization is one in which all the nine biological phenomena are taken into consideration by the subject but are not organized in a total, inclusive and comprehensive manner. They are organized into two or more substructures which do not appear to be related to each other. For example, "Three are

structures, six are functions," "Cells contain cytoplasm and nucleus and are surrounded by a cell membrane. The cells obtain energy by means of cellular respiration which is a part of their total metabolism and carry on certain processes such as reproduction and growth. They are able to make an adaptation to a new situation and often protect themselves from unfavorable stimuli by movement away from it."

A narrow organization is least comprehensive of all. The subject omits one or more of the objectively present phenomena from his organization. Examples of this pattern of thinking, as presented by the subjects, are: "Some of these are necessary functions of living matter." "Cell membrane, nucleus, and cytoplasm are cell structures." "Metabolism and growth lead to reproduction." "The nucleus governs the metabolism, growth and reproduction of the cell."

Each subject was rated, on the basis of the above definitions, and placed into one of the three categories: comprehensive, isolated, or narrow. To make the categorization more accurate two other persons served independently as judges. Classifying into these three groups was found to be relatively simple and agreement of all three judges was necessary. If the judges

disagreed the case was discussed and if no agreement was then obtained that particular organization was omitted. There were only six papers discarded on this basis. There was no reliability coefficient obtained of the independent judgments of the judges. It was also necessary that the subjects show evidence in his definitions of understanding the phenomena listed for his perusal. Actually, the concern is not whether or not the statements made by the subjects in his paragraph are correct or not—what is important in this study is the type of organization that is attempted by the subject. And it is the organization that is being rated here.

A statistical analysis of the resulting data of 130 subjects showed the following results (Table V). On the basis of rigidity, as arrived at by the arithmetic technique, the non-rigid group had 38 comprehensive organizations whereas the rigid group had 22 comprehensive organizations. The chi-square test of the significance of this difference was found to be 7.922 which is significant above the 1% level. The non-rigid group was found to have 15 isolated organizations, while the rigid group had 19. By use of the chi-square test there was found to be no significant difference between the two groups. The non-rigid group was found to have 12 narrow organizations while the rigid group had 24. The

TABLE V

COMPARISON OF RIGID AND NON-RIGID GROUPS ON COMPREHENSIVE, ISOLATED AND NARROW COGNITIVE ORGANIZATIONS

N Rigid 65	N Non-Rigid 65		
	Comprehensive	Isolated	Narrow
Non Rigid	38	15	12
Rigid	22	19	24
X^2	7.922	-	5.30
Significance Level	1%	-	2%

chi-square test of this was found to be 5.530, with a significance level of 2%. The chi-square test of the total was found to be 8.737 with two degrees of freedom and to be significant above the 2% level.

Table VI gives the data concerning those high and those low on ethnocentrism. The highs had 38 comprehensive organizations, while those low on ethnocentrism had 47. This was significant at the 20% level. On the basis of isolated organizations the highs had 25 and the lows 23. This was not significant at all. On the basis of the number of narrow organizations the highs had 28 and the lows 21, which was significant at the 30% level. None of these

TABLE VI

COMPARISON OF THOSE HIGH AND OF THOSE LOW ON ETHNOCENTRISM ON COMPREHENSIVE, ISOLATED AND NARROW COGNITIVE ORGANIZATION

N Highs 91	N Lows 91		
	Comprehensive	Isolated	Narrow
Highs	38	25	28
Lows	47	23	21
X^2	1.7878	-	1.364
Significance Level	20%	-	30%

results, showed any reasonable degree of significance. The chi-square test of the total was found to be 2.036 with two degrees of freedom and a significance level of 50%. These results do not agree with those found by Rokeach.[3] It may well be that this difference in results is due to the fact that this portion of the work has been utilizing groups based on reaction to the social phenomena of ethnocentrism and their response to biological phenomena, whereas Rokeach has been using groups designated on the same basis but

[3] Ibid., pp. 97-104.

measuring their reaction to social phenomena of the same category. As on the previous experiment regarding the scientific method items, differences are far more clearcut when using the criterion of rigidity than when using a manifestation of rigidity such as ethnocentrism.

The above data infers that the hypothesis presented was upheld by the results described. That individuals relatively less rigid in their thinking processes do exhibit a pattern of thinking that is more comprehensive than a group whose thought processes are more rigid and, consequently, whose pattern of thinking more isolated and narrow. It becomes evident with the completion of this portion of the study that it would be interesting to investigate the possibility, which is certainly in line with the entire study, of a relationship between comprehensive organization and the ability to perform on scientific method items as presented in the previous study. Therefore the following hypothesis was formulated and tested: a group of individuals who are more comprehensive in their thought processes will do better in the solving of scientific method items than a group of individuals who show a thought process that is isolated and/or narrow. The means of testing this hypothesis was the standard error of the difference of the means

of the results of the scientific method test. Table VII presents the statistical results of the testing of the hypothesis as to the significance of the difference of the means of the scores on the scientific method items between subjects with a comprehensive structure and isolated structures, between comprehensive and narrow structures, and between isolated and narrow structures.

TABLE VII

COMPARISON OF SUBJECTS CATEGORIZED AS COMPREHENSIVE, ISOLATED AND NARROW AND ABILITY TO WORK SCIENTIFIC METHOD ITEMS

	Mean	S.D.	S.D.D.	CR	Sig. Level
Comprehensive	19.77	2.35	.796	1.118	30%
Isolated	18.88	4.1			
Isolated	18.88	4.1	1.092	1.68	10%
Narrow	17.04	5.26			
Comprehensive	19.77	2.35	.896	3.141	1%
Narrow	17.04	5.26			

The results as shown in Table VII indicate that there is little or no significant difference between the means of the comprehensive and isolated groups. Their ability to work scientific method items is, evidently, almost equivalent. The difference between the

isolated and narrow is at the 10% level and while it is not significant within the limits set for this problem it does suggest a trend towards significance. The most interesting and clear-cut result is that obtained when the difference of the means of the comprehensive and narrow groups are studied. Here it is found that the difference is highly significant, at above the 1% level. The comprehensive group of subjects is evidently better able to work scientific method items. It should be pointed out that, while there is no significant difference between comprehensive and isolated groups or between the isolated and narrow groups, there is the trend in all of the results that suggests a continuum. The comprehensive group has the highest score, the isolated group the next highest scores, and the narrow group the lowest scores. The trend of the scores is in the hypothesized direction. Therefore, on the basis of the statistical analysis of this data, the hypothesis is confirmed.

CHAPTER V

RIGIDITY AND COMPREHENSIVENESS IN THE NORMAL CLASSROOM SITUATION

This chapter consists of the testing of the third major hypothesis to the effect that the rigid-non-rigid personality structure and the comprehensive cognitive pattern is operative in a normal classroom situation. This hypothesis was tested by comparing the performance of rigid and non-rigid groups, groups high and low on the ethnocentric scale, and groups showing comprehensive and non-comprehensive cognitive patterns on certain designated portions of an experimental laboratory study performed in the classroom.

Design and instructions for the study. The testing of this hypothesis was accomplished by comparing the performance of the above mentioned groups on a laboratory problem entitled, "Adjustment and Coordination in Plants."[1] In essence this problem[2] deals with a series of rather simple experiments dealing

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[1] Department of Biological Science, Guide for Laboratory Studies in Biological Science (East Lansing: Michigan State College Press, 1949), pp. 137-144.

[2] See Appendix C.

with plant hormones and light in relationship to growth. The student usually comes to the laboratory with the preconceived idea that light aids plant growth directly with the result that plants grow more during the day than during the night. If the subject works through the study correctly he will come out with the information, based upon experimental results, that light inhibits growth in plants. This should lead to the inference that plants grow more during the night than during the day.

The biologists who designed this laboratory exercise adapted the materials from the original experiments covering this phase of knowledge. This exercise was specifically designed as a study that deals with a series of simple experiments whose results can be utilized in the formulation, testing, and modification of hypotheses. It is considered that this study is one of the best laboratory exercises in the course of Basic Biological Science at Michigan State College for its assumed value in teaching the methods of science.

The introduction to the laboratory study being utilized in this report states that:

> There are certain areas in science where the thinking and experimental processes have been so clear and concise that they have become classics. . . . In this century some

> of the work on hormones has been of this type and will probably become classical as time passes.
>
> Our problem today deals with a series of rather simple experiments whose results can be used in the formulation, testing, and modification of hypotheses.[3]

The specific factual information of this study has not been covered before in the classroom, but those aspects concerned with scientific methodology have been studied previously. The study, as has been noted above, deals with a number of experiments whose results can be utilized in the formulation, testing, and modification of hypotheses. This type of work has been part of the work in the laboratory portions of both the first and second terms of the course. There has been a constant and consistent effort made throughout the laboratory portion of the course to inculcate the idea that the formulation, testing, and modification of hypotheses is one of the foremost aspects of the scientific method. There has been ample opportunity in all of the laboratory studies to practice this aspect of scientific methodology.

The conduct of the laboratory was as follows: There is one laboratory period per week which meets for two hours. Up to this point in the course the student has had thirteen laboratory

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[3] Ibid., p. 137.

studies. The laboratory class meets for two hours under the direction of a member of the staff of the Department of Biological Science. In this study, as in other studies, the student was given two hours to complete the problem. Ordinarily the instructor may assist or guide the student in the work of the day, however, in this particular study as part of this experimental study, the students were asked to work through the study without assistance from the instructor.

Before beginning the study the subjects were asked to answer the following questions on a worksheet (Figure 6) before proceeding with the laboratory exercise, so as to discover and establish any preconceived ideas and factual information that the subjects may have pertaining to the study: (1) How do plants adjust and coordinate to the factors in the environment? (2) Why do plants bend towards light? (3) Do plants grow more during the daytime or during the night-time? Why? Upon the completion of the answers to these questions the subjects then turned to the laboratory exercise. At the completion of the laboratory exercise the subject was again asked to answer some questions on a worksheet pertaining to the study (Figure 7). These questions were designed to gain knowledge as to: (1) the ability of the subject to

Name_____

Instructor_____

Please answer the following questions to the best of your ability. This will in no way influence your grade in this course.

1. How do plants adjust and coordinate to the factors in the environment?

2. Why do plants bend towards light?

3. Do plants grow more during the daytime or during the nighttime? Why?

FIGURE 6

WORK SHEET PERTAINING TO QUESTIONS ASKED PRIOR TO WORKING THE LABORATORY STUDY

Name_____

Instructor_____

Please answer the following questions to the best of your ability. This will in no way influence your grade in this course.

1. How do plants adjust and coordinate to the factors in the environment?

2. Why do plants bend towards light?

3. Do plants grow more during the daytime or during the nighttime? Why?

4. What is the relationship of light to growth in the higher green plants?

5. Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why?

FIGURE 7

WORKSHEET PERTAINING TO QUESTIONS ASKED AFTER COMPLETION OF LABORATORY STUDY

work through the exercise and arrive at predetermined correct solutions; (2) the rejection or retention of preconceived ideas in light of new knowledge gained on the basis of experimentation; and (3) the ability of the student to judge correctly valid experiments and experimental results. The questions were as follows: (1) How do plants adjust and coordinate to the factors in the environment? (2) Why do plants bend towards light? (3) Do plants grow more during the daytime or during the night-time? Why? (4) What is the relationship of light to growth in the higher green plants? (5) Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why? It was expected that on the basis of the answers given to the foregoing sets of questions that some knowledge would be gained as to the performance of the subjects of the study in relation to rigidity, ethnocentrism, and comprehensiveness of cognitive patterns.

Results. An important consideration in this portion of the work concerns the judgment of the answers given to the questions on the worksheets shown in Figures 6 and 7. The answers to all questions were judged by two biologists and complete agreement as to correctness of the answer was necessary on the part of the

judges. If the judges did not agree the subject was eliminated from this experiment. In order to answer questions correctly the various factors of light, growth and bending of plants must have been taken into consideration by the student. The subject must have shown as complete an understanding of these factors as was possible on the basis of the knowledge gained in the study.

The first analyses of results were made to determine whether there existed any differences in the correctness of responses between the non-rigid and rigid groups, between those high and those low on ethnocentrism, and between the comprehensive and non-comprehensive groups to like questions on the worksheets: questions one, two, and three (Figures 6 and 7). These questions were the same and so comparison could be made on a "before" and "after" basis. That is, before the beginning of the study and after the completion of the laboratory study. The following information was obtained and tabulated in Tables VIII, IX, and X concerning the "before" and "after" responses to the question, "How do plants adjust and coordinate to the factors in the environment?" It can be seen from Table VIII that only eight of the rigid category of sixty-eight subjects and eleven of the non-rigid category of sixty-eight subjects were able to answer

TABLE VIII

COMPARISON OF RIGID AND NON-RIGID GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION ONE BEFORE AND AFTER COMPLETION OF LABORATORY STUDY

	N Rigid 68		N Non-Rigid 68	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Rigid	8	60	33	35
Non-Rigid	11	57	43	25
X^2	.548		3.080	
Significance level	50%		10%	

the question correctly. The chi-square of this difference is 0.548 with one degree of freedom and with significance at the 50% level. This is not a rejection of the null hypothesis and it can therefore be inferred that on the basis of these results the two groups, rigid and non-rigid, are equal in their ability to answer the question correctly before working the laboratory study. A further study of Table VIII reveals that of the rigid group of sixty-eight subjects thirty-three subjects gave correct responses, and of the sixty-eight

TABLE IX

COMPARISON OF THOSE HIGH AND THOSE LOW ON ETHNOCENTRISM AS TO CORRECTNESS OF RESPONSE TO QUESTION ONE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

	N Highs 85		N Lows 87	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Highs	10	75	45	40
Lows	14	73	48	39
X^2	.192		.092	
Significance level	70%		80%	

non-rigid subjects forty-three gave correct responses after finishing the study. The chi-square of this difference was 3.080 with one degree of freedom with significance at the 10% level. While the significance level is not high enough to completely reject the null hypothesis, it is indicative of a trend for those who were non-rigid to respond correctly to this question.

Table IX presents the before and after comparison of the responses given to the first question by those high and those low

TABLE X

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION ONE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Comprehensive 46	N Isolated 47		N Narrow 43	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Comprehensive	3	43	32	14
Isolated	2	45	24	23
Narrow	3	40	17	26
X^2	.359		8.2587	
Significance level	90%		2%	

on the California E-scale. Ten of the eighty-five highs and fourteen of the eighty-seven lows gave a correct response before the completion of the laboratory exercise. The chi-square of this difference is 0.192 with one degree of freedom with significance at the 70% level. This signifies the retention of the null hypothesis. Comparison of the two groups after the completion of the study shows that of the eighty-seven lows forty-eight had correct

responses whereas forty-five of the eighty-five highs had correct responses. Again the null hypothesis is retained for the chi-square of this difference, with one degree of freedom, is 0.092, with significance at the 80% level.

The third grouping, analyzed on the basis of the first question, concerned the comprehensive, isolated and narrow cognitive structures. A perusal of Table X showed that before the completion of the laboratory study three of the forty-six comprehensive subjects, two of the forty-seven isolated subjects, and three of the forty-three narrow subjects answered the question correctly. The chi-square of these differences amounted to 0.359 with two degrees of freedom and a significance level of 90%. This indicated retention of the null hypothesis. After the completion of the laboratory study the comprehensive group had thirty-two correct responses, the isolated group twenty-four correct responses, and the narrow group had seventeen correct responses. This gave a chi-square of 8.2578 with two degrees of freedom and a significance level of 2%. The 2% significance level indicated a rejection of the null hypothesis and it may be inferred that the difference is due to the greater comprehensiveness of the comprehensive group.

The next series of analyses concerned the second question, "Why do plants bend towards light?" Table XI gives the data showing the responses of the rigid and non-rigid groups of subjects. Two of the sixty-eight rigid and one of the sixty-eight non-rigid individuals gave a correct response before the beginning of the laboratory exercise. The chi-square of this difference was 0.338 with a significance level of 70%. After the completion of the laboratory study there were twenty-two rigid individuals and thirty non-rigid subjects giving a correct response. The chi-square of this difference was 1.990 with a significance level of 20%. While this is not high enough for complete rejection of the null hypothesis, it does indicate a trend towards a significance level of some meaning. It might be inferred that while the rigid and non-rigid groups are equivalent in their ability to answer the question before the beginning of the laboratory exercise, the non-rigid group tends to do better than the rigid group after the completion of the study.

Neither the group high on the E-scale nor the group low on the E-scale showed a significance level, either before or after the completion of the laboratory study, which could be taken to

TABLE XI

COMPARISON OF RIGID AND NON-RIGID GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION TWO BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

	N Rigid 68		N Non-Rigid 68	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Rigid	2	66	22	46
Non-Rigid	1	67	30	38
X^2	.338		1.990	
Significance level	70%		20%	

mean a rejection of the null hypothesis. A perusal of Table XII will present the data. It will be noted that in both the before and after situations the significance level reached was 70%.

The performance of the comprehensive, isolated, and narrow groups on question two was also without a significance level necessary for the rejection of the null hypothesis. A perusal of Table XIII will show that in each case, before and after the study, the significance level reached was 50%, which is not enough

TABLE XII

COMPARISON OF THOSE HIGH AND OF THOSE LOW ON ETHNOCENTRISM AS TO CORRECTNESS OF RESPONSE TO QUESTION TWO BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

	N Highs 85		N Lows 87	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
High	3	82	28	57
Low	2	85	26	61
X^2	.226		.185	
Significance level	70%		70%	

to reject the null hypothesis. It may be inferred that the two groups show equal ability to answer the question both before and after the working of the laboratory study.

The last analysis of this "before" and "after" series concerns the third question (Figures 6 and 7), "Do plants grow more during the daytime or during the night-time? Why? The rigid and non-rigid groups before beginning the laboratory study were considered, as shown in Table XIV, to be equivalent on this question

TABLE XIII

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION TWO BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Comprehensive 46	N Isolated 47		N Narrow 43	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Comprehensive	1	45	21	25
Isolated	0	47	16	31
Narrow	2	41	15	28
X^2	2.150		1.629	
Significance level	50%		50%	

as the significance level of the difference of the correct responses was at the 70% level. The rigid group had one correct response out of sixty-eight subjects, and the non-rigid group had two correct responses out of sixty-eight subjects. The significance level of this difference was 70% and, therefore, the null hypothesis was retained. After the completion of the laboratory study the rigid group had seventeen correct responses, and the non-rigid group

TABLE XIV

COMPARISON OF THE RIGID AND NON-RIGID GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION THREE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

	N Rigid 68		N Non-Rigid 68	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Rigid	1	67	17	51
Non-Rigid	2	66	28	40
X^2	.338		4.016	
Significance level	70%		5%	

had twenty-eight correct responses. The chi-square of this difference was 4.016 and was significant at the 5% level. The null hypothesis can be rejected at this level with the inference that the difference obtained cannot be fully ascribed to chance or sampling fluctuations, but to the difference in rigidity of the two groups.

Table XV presents the data for responses to the third question as concerns those groups high and low on ethnocentrism.

TABLE XV

COMPARISON OF THOSE HIGH AND OF THOSE LOW ON ETHNOCENTRISM AS TO CORRECTNESS OF RESPONSE TO QUESTION THREE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

	N Highs 85		N Lows 87	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
High	2	83	18	67
Low	1	86	17	70
X^2	.360		.070	
Significance level	70%		80%	

It can be seen that before beginning the study the highs had two correct responses out of eighty-five subjects, and the lows had had one correct response out of eighty-seven subjects. The significance level of this difference was 70%, which meant that the null hypothesis was retained. After the completion of the study the highs showed eighteen correct responses and the lows seventeen. The significance level of this difference was at the 80% level. Therefore, in neither case, before or after the study, was

there, statistically, a difference between the highs and lows as concerns correct responses to the question.

The data on the comprehensive, isolated, and narrow groups for the before and after responses to the third question is presented in Table XVI. There was no statistical difference in the number of correct responses given before the working of the laboratory study. The significance level was at the 99% level. However, at the completion of the exercise the comprehensive cognitive group had nineteen out of forty-six individuals give correct responses; the isolated cognitive group had seventeen out of forty-seven individuals give correct responses; and the narrow cognitive group had nine out of forty-three individuals give correct responses. The chi-square of these differences was 4.465 with a significance level of 20%. While this is not quite high enough to reject the null hypothesis completely, there is, certainly, indicated a trend in the hypothesized direction of rejection rather than toward retention of the null hypothesis.

To summarize the "before" and "after" series, for which the statistical data has just been presented, it may be said that the data seem to indicate that in the case of the rigid and non-rigid groups there was a statistical trend in two of the questions

TABLE XVI

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW GROUPS AS TO CORRECTNESS OF RESPONSE TO QUESTION THREE BEFORE AND AFTER COMPLETION OF THE LABORATORY STUDY

N Comprehensive 46	N Isolated 47		N Narrow 43	
	Before Study		After Study	
	Correct Responses	Incorrect Responses	Correct Responses	Incorrect Responses
Comprehensive	1	45	19	27
Isolated	1	46	17	30
Narrow	1	42	9	34
X^2	.003		4.465	
Significance level	99%		20%	

towards a suitable significance level, and in one case there was rejection of the null hypothesis on the 5% level. There was no statistical evidence showing any difference in response to the questions as far as the groups high and low on the California Ethnocentric Scale were concerned. In the case of the groups classified as comprehensive, isolated, and narrow in their cognitive structure, in one question there was no before and after difference

shown statistically. In another question the significance level attained of 20% indicated a trend in the hypothesized direction. The third showed results at the 2% level indicating quite a decided difference between the comprehensive, isolated, and narrow groups, and this was in the hypothesized direction.

As it was not possible in this particular laboratory study to obtain information on all of the eighteen elements of the scientific method as previously listed,[4] only a few were selected for study. It was possible to obtain information as to the ability of the subjects to recognize a valid experiment when confronted by one. As heretofore stated, the laboratory study was adapted from the original experiments covering this phase of knowledge. It was the opinion of the biologists writing this study that the experiments were valid and confirmed the hypotheses that were being tested. The information for this study was obtained directly from the subjects by simply asking them, "Do you consider that the series of experiments in this laboratory study are sound and valid and can be used to answer the above questions? Why?" The answers were judged by two biologists and complete agreement was necessary

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[4] See Chapter III.

for acceptance. If the judges did not agree the subject was eliminated from this experiment. The following information was obtained and tabulated in Table XVII. It can be seen that forty-eight of the non-rigid group and thirty-eight of the rigid group of sixty-eight individuals in each group, agreed that the experiments were sound and valid. The significance level of this difference was above 10%. Eleven of the non-rigid and sixteen of the rigid category remained neutral in their answers—giving neither a distinctly affirmative nor a distinctly negative answer to the question. Of those categorized as non-rigid, nine gave a negative answer, as did fourteen of the rigid group. The significance of the difference here was above 30%. The chi-square of the total table is 3.175 with two degrees of freedom for a significance level of close to 20%. When categorized on the basis of the California Ethnocentric Scale no difference at all was found between the high and the low scorers. This was also true when using comprehensiveness as a criterion. It is interesting to note that in the testing for this element by use of the scientific method test items, as in Chapter III, no significant differences were found by using either rigidity or ethnocentrism as the criteria of division into groups.

TABLE XVII

COMPARISON OF RIGID AND NON-RIGID GROUPS AS TO VALIDITY OF LABORATORY STUDY EXPERIMENTS

	N Rigid 68		N Non-Rigid 68	
	Answered "Valid	Neutral	Answered "Not Valid"	Total
Non-Rigid	48	11	9	68
Rigid	38	16	14	68
X^2	3.1626	1.1550	1.3080	
Significance level	10%	30%	30%	

The element of causal relationships can also be studied here. The question on Figure 7, "What is the relationship of light to growth in the higher green plants?" can get at this factor. The working of the series of experiments contained in the laboratory study leads to the cause and effect relationship among the factors of light, growth, and bending in plants. Tables XVIII and XIX present the data gathered in this phase of the report. A perusal of Table XVIII shows that twenty-two rigid and thirty-one non-rigid, each out of a group of sixty-eight subjects, were able to see causal relationships existing between the factors of light,

TABLE XVIII

COMPARISON OF RIGID AND NON-RIGID GROUPS RELATIVE TO CAUSAL RELATIONSHIPS

N Rigid 68		N Non-Rigid 68		
	Rigid	Non-Rigid	X^2	Significance Level
Recognition of Causal Relationships	22	31	2.502	20%
Non-Recognition of Causal Relationships	46	37		

growth, and bending. The chi-square of this difference was 2.502 and was significant at the 20% level. There was no observable statistical difference between the group high and the group low on ethnocentrism as is indicated in Table XIX. On the basis of the type of cognitive structure it was seen, as shown in Table XX, that the chi-square of the observed difference was 3.574 with two degrees of freedom for a significance level of 20%. In the case of the groups classified on degree of ethnocentrism, Table XIX indicates the null hypothesis is retained on the basis that there is no statistical difference between the two groups. On the groupings

TABLE XIX

COMPARISON OF A GROUP HIGH AND OF A GROUP LOW IN ETHNOCENTRISM RELATIVE TO CAUSAL RELATIONSHIPS

N Highs 85		N Lows 87		
	Highs	Lows	X^2	Significance Level
Recognition of Causal Relationships	27	26	.068	50%
Non-Recognition of Causal Relationships	58	61		

based on cognitive structure Table XX indicates that the significance level, as stated, was 20% which, on the basis of the standard set for this report, is a trend in the hypothesized direction.

Arriving at an answer to a problem through a valid experiment does not guarantee that this new bit of information will have any meaning to the investigator as far as ridding himself of a preconceived notion. For instance, many of the students have the preconceived teleological idea that plants bend towards light because the plant needs light and will therefore exert itself to get to the

TABLE XX

COMPARISON OF COMPREHENSIVE, ISOLATED, AND NARROW COGNITIVE GROUPS RELATIVE TO CAUSAL RELATIONSHIPS

N Comprehensive 46		N Isolated 47		N Narrow 43	
	Comprehensive	Isolated	Narrow	X^2	Significance Level
Recognition of Causal Relationships	23	16	14	3.574	20%
Non-Recognition of Causal Relationships	23	31	29		

light. Regardless of how the idea arose, the important question here is whether experimental evidence will overthrow a preconceived idea. It is well within the definition of rigidity to postulate that the non-rigid individual will be more receptive, more open to evidence, will be less hesitant in utilizing evidence to the contrary to a long held idea. By comparing the responses to the question, "Why do plants bend towards light?" answered before and after the working of the laboratory exercise, of students who successfully[5] completed the exercise, it is possible to see how many

[5] According to the discernment of the judges.

subjects changed their ideas on this question when the evidence was available through their own efforts. Using the criterion of rigidity it was found, as shown in Table XXI, that fifteen of the thirty-two rigid and twenty-six of the forty-one non-rigid, who completed the exercise correctly according to the discernment of the judges, accepted the experimental evidence and modified their ideas to fit the new facts. The chi-square of this difference was found to be 2.0007 with one degree of freedom giving a significance level of above 20%. This indicates a trend towards a suitable level necessary for the rejection of the null hypothesis. With the separation of the subjects into highs and lows on the basis of the scores on the California Ethnocentric Scale, or on the basis of comprehensive and non-comprehensive thought patterns, no significant differences were obtained.

It was hypothesized that the value of comprehensiveness is operative in the classroom situation. It has been indicated that upon the testing of this hypothesis on the basis of the elements of the scientific method no clear cut significant differences between subjects with comprehensive or non-comprehensive cognitive patterns were shown. However, this hypothesis can be tested upon another basis. It is assumed that those subjects who are

TABLE XXI

COMPARISON OF RIGID AND NON-RIGID GROUPS SUCCESSFULLY COMPLETING LABORATORY STUDY ON ACCEPTANCE OF EXPERIMENTAL EVIDENCE AND MODIFICATION OF IDEAS

N Rigid 32		N Non-Rigid 41
	Acceptance of Evidence	Non-Acceptance
Rigid	15	17
Non-Rigid	26	15
X^2	2.0007	
Significance Level	20%	

more comprehensive in their mental organization are better able to organize the factual information derived from this series of experiments in the laboratory study, and therefore have a greater success in arriving at a correct solution of the problem at hand. Successful completion of the laboratory study was determined by the judges as meaning that the subjects were able to answer all of the questions on Figure 7, showing that they had been able to complete the exercise, and understanding the various relationships of light, growth, and bending in the plant. The students finishing the

laboratory exercise successfully were assumed to have been able to integrate the materials and evidence of the problem into a comprehensive whole, and therefore to arrive at an acceptable conclusion. The subjects were categorized on the basis of their cognitive organization pattern into comprehensive, isolated, and narrow groups. Table XXII gives the data of the analysis. In comparing the comprehensive with the isolated group, it is seen that there were thirty-two successful and correct completions of the study for the comprehensive group as compared with twenty-four for the isolated group. The chi-square of this difference is 3.2966 with significance at the 10% level. This indicates a trend towards rejection of the null hypothesis. Upon comparison of the isolated and narrow groups no significant difference is found for the significance is at the 30% level. It is upon viewing the comprehensive and narrow groups in relation of one to another that a high level of significance is found, at above the 1% level. Taking all three groups in relation to each other, the chi-square, with two degrees of freedom, is 8.2587, which is significant at the 2% level. This means for the table as a whole there is a rejection of the null hypothesis, and on the basis of this data the hypothesis may be considered to have been confirmed. It may be noticed that the trend is

TABLE XXII

COMPARISON OF THOSE CATEGORIZED AS COMPREHENSIVE, ISOLATED AND NARROW WITH ABILITY TO SOLVE LABORATORY PROBLEMS

N Comprehensive 46		N Isolated 47	N Narrow 43	
	Correct Completion	Incorrect Completion	X^2	Signif-icance Level
Comprehensive	32	14	3.2966	10%
Isolated	24	23		
Isolated	24	23	1.2595	30%
Narrow	17	26		
Comprehensive	32	14	8.1037	1%
Narrow	17	26		

from a greater number of correct and complete solutions from the comprehensive group down to the isolated group and from there to the narrow group. It appears to be in the form of a continuum with complete comprehension at one end and complete narrowness at the other end.

CHAPTER VI

DISCUSSION OF RESULTS

The data collected in this report from the duplication of the researches of Rokeach[1] sustain the hypothesized generalized mental rigidity. The data indicated that individuals who are high scorers on the California Ethnocentric Scale were also rigid as measured by the arithmetic technique; and individuals who are low scorers on the California Ethnocentric Scale were also non-rigid as measured by the arithmetic technique.

The work of Rokeach[2] extended the hypothesis of generalized mental rigidity from the sphere of the solution of social problems to that of the solution of non-social problems. This extension rests on the basis of the use of the arithmetic and spatial techniques. The work of Adorno, Frenkel-Brunswick, Levinson, Sanford[3] goes further and suggests that ethnocentric

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[1] Milton Rokeach, "Generalized Mental Rigidity As A Factor in Ethnocentrism," The Journal of Abnormal and Social Psychology, 43:259-278, July, 1948.

[2] Loc. cit.

[3] T. W. Adorno and others, The Authoritorial Personality, (New York: Harper and Brothers, 1950) pp. 990.

individuals will solve various problems in a rigid and stereotyped manner. They also state that ethnocentric individuals express a definite anti-scientific attitude.

The results of the present report lend further support to the hypothesis of a generalized mental rigidity. The data secured here suggest that the hypothesized general rigidity extends to the ability to utilize the elements of the scientific method. The data seem to indicate that a rigid group of individuals cannot solve problems dealing with the elements of the scientific method as well as a non-rigid group of individuals.

This report went beyond the addition of evidence supporting the hypothesized generalized mental rigidity. The work was extended to delve into at least one aspect of the thinking pattern exhibited by the rigid and non-rigid individuals. The data seem to indicate that non-rigid individuals show a more comprehensive pattern of thinking than rigid individuals. The scope of thought of the non-rigid individuals seems to be wider, they appear to have the ability to see broad and general relationships. The rigid individuals, on the other hand, seem to have a more narrow pattern of thought. They do not appear to possess an equal ability to see and to state broad and general relationships.

Perhaps the most important results appear to indicate that the effectiveness of the teaching of the scientific method is

possibly, at least partially, determined by the rigidity-non-rigidity and the comprehensiveness-non-comprehensiveness of the student. The data indicate that, in general, on the basis of the ability to perform an experimental laboratory problem utilizing the elements of the scientific method, the non-rigid group of individuals were statistically superior. The evidence indicated that, in general, the rigid and non-rigid groups were equivalent in their knowledge pertaining to the laboratory problem before the working of the problem, but after completion of the problem the non-rigid group was able to give more correct responses to the problem than the rigid group. The non-rigid group appeared to be able to learn more than the rigid group of individuals as far as this particular problem was concerned. The data indicated a trend, statistically, in the direction of a greater ability to recognize a valid experiment on the part of the non-rigid group as compared with the rigid group of individuals. The data appeared to indicate a trend in the direction of a greater ability on the part of both the non-rigid group and the comprehensive group, as compared with the rigid and non-comprehensive groups respectively, to recognize causal relationships. The data also seemed to indicate a trend, statistically, in a greater ability on the part of the non-rigid group to overthrow

preconceived ideas on the basis of experimental evidence. There appeared to be a greater over-all ability on the part of the comprehensive group to assimilate and organize the factual information obtained from the laboratory problem and on the basis of this arrive at a correct solution to the problem being worked.

An examination of the scientific method test items utilized in this study indicates that they require for their solution not only the necessary factual information, but more significantly they require the ability to see the relationships existing among the facts concerned to the required answer. On the basis of the data derived from a comparison between the rigid and non-rigid groups, the non-rigid individuals are apparently better able to see these existing relationships. The difference between the two groups is at the 1% level. The data likewise indicate that the comprehensive group of individuals, as compared to the narrow group, also show a greater ability to answer correctly the scientific method test items. This difference is significant at the 1% level. One can infer from these two sets of data that, if the non-rigid individuals and the comprehensive individuals can both do significantly better than the rigid and the non-comprehensive groups respectively, there is a relationship between non-rigidity and a comprehensive cognitive structure. Further evidence of

this relationship is indicated by a study of the data derived from a comparison of rigid and non-rigid individuals as to their comprehensive and non-comprehensive cognitive structures. The data indicates that the non-rigid group as compared to the rigid group had a greater ability to see and state broad and general relationships concerned with biological phenomena. This is indicated by the fact that the non-rigid group has a greater number of comprehensive cognitive structures as compared to the rigid group. This difference is also significant at the 1% level. The data also indicate that the rigid group of individuals have a narrow cognitive structure. The results indicate that the rigid group had significantly more, at the 2% level, narrow organizations than the non-rigid group.

An analysis of the data concerning the laboratory problem likewise suggests a relationship between rigidity and comprehensiveness. Upon analysis of the data pertaining to the answers to the first question before the problem was begun there was no statistically significant difference as to amount and correctness of factual information between the rigid and non-rigid groups and between the comprehensive and non-comprehensive groups. But upon completion of the problem the non-rigid group showed a trend in the hypothesized direction, at the 10% level, toward a

significant difference and the difference, in the hypothesized direction, between the comprehensive and non-comprehensive groups was at the 2% level. Again there is indicated a relationship between non-rigidity and comprehensiveness. The response to the second question showed a difference only at the 20% level in favor of the non-rigid group. The comprehensive and non-comprehensive groups show no significant difference at all. The results for the third question indicate that the difference between the rigid and non-rigid groups is at the 5% level, while for the comprehensive and non-comprehensive groups the difference is at the 20% level and both are in the hypothesized direction. The results, taken as a whole, seem to indicate relationship between non-rigidity and comprehensiveness.

The question arises as to the reason for the difference in ability between the rigid and non-rigid groups to solve the scientific method test items. The rationale for this is in terms of the comprehensive and non-comprehensive cognitive structures. That there is a relationship between non-rigidity and comprehensiveness of cognitive structure has been indicated above. The rigid individuals seem to show an inability to go beyond the mere factual information at hand and react on the basis of each individual fact separately. The rigid group does not indicate the ability to

see a relationship of one piece of factual information to others. The individuals of the rigid group may even simply refuse to consider some of the facts that are at their command. That the rigid individual does act in this manner is indicated in the analysis of the organizational approach used by the subjects on the interrelationships work sheet (Figure 5).

The non-rigid individual, on the other hand, has the ability to see and to state the relationships existing and necessary for the correct solution of the problem. The data gathered from the interrelationship work sheet (Figure 5) indicates that the comprehensive group can take the individual facts under consideration and organize them into a single unified structure. The thought processes are broad and integrated and take all of the pertinent facts into consideration in arriving at a solution to the problem.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Summary of the study. The principal purpose of this study was to compare a group of individuals classed as relatively rigid in their thinking process with a group of individuals categorized as relatively non-rigid in their thinking process as to: (1) their reaction to various aspects of the scientific method; (2) the comprehensiveness of their patterns of thinking; and (3) their performance on a Biological Science laboratory study in the normal classroom situation. A further purpose was to independently check the work of Rokeach[1] on generalized mental rigidity so as to determine to what extent this work is valid.

The general plan consisted of the following procedures. The first step consisted of utilizing an arithmetic technique in order to establish two groups of subjects: one designated as relatively rigid in the thinking process, and the other categorized as relatively non-rigid in its patterns of thought. The second step consisted of designating subjects as "low" or "high" on the basis

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[1] Milton Rokeach, "Generalized Mental Rigidity As A Factor in Ethnocentrism," The Journal of Abnormal and Social Psychology, 43:259-278, July, 1948.

of scores obtained on the California Ethnocentric Scale. The third step consisted of obtaining groupings categorized as comprehensive, isolated, and narrow cognitive structures on the basis of an interrelationships scale administered to the subjects of the experiment.

With the establishment of these groups it was possible to test the following hypotheses: (1) a group of individuals who manifest a rigidity in the thinking process will react differently to the various factors concerned with the scientific method than a group of individuals who are relatively less rigid in their thinking pattern; (2) a group of individuals relatively less rigid in their thinking processes will exhibit a pattern of thinking that is more comprehensive than a group whose thought processes are more rigid and, consequently, whose pattern of thinking is isolated and narrow; and (3) the rigid personality structure and the comprehensive cognitive pattern will be found operative in a normal classroom situation which requires for the solution of a problem the use of the elements of the scientific method.

The first hypothesis was tested by comparing the performance of groups specified as rigid and non-rigid on a test containing items concerning the elements of the scientific method. The groups designated as the "lows" and the "highs" on the

California Ethnocentric Scale were also compared on this basis, the second hypothesis was tested by comparing rigid and non-rigid groups as to the number of comprehensive, isolated, and narrow cognitive organizations exhibited by each. The groups designated as the "highs" and the "lows" on the California Ethnocentric Scale were also compared as to the number of comprehensive, isolated, and narrow cognitive organizations exhibited by each. The following minor hypothesis was formulated and tested: individuals who are more comprehensive in their thought processes will do better in the solving of scientific method test items than a group of individuals who are non-comprehensive in their cognitive structure. This was tested by comparing the means of the scores on the scientific method test items between subjects with a comprehensive structures and isolated structures; between subjects with comprehensive and narrow structures. The third major hypothesis was tested by comparing the performance of rigid and non-rigid groups; groups that are "high" and "low" on the ethnocentric scale; and comprehensive and non-comprehensive groups on an experimental laboratory study in a normal classroom situation.

Results and conclusions. The statistical analysis of the data obtained in the study was based upon the testing of the null

hypothesis. The results of analysis which showed a significance level of above 5% were arbitrarily considered to be a rejection of the null hypothesis, and that at this level the differences obtained cannot be fully explained by sampling fluctuations. Significance levels between the 20% and the 5% level, while not large enough to reject the null hypothesis completely, were retained on the assumption that these levels at least indicate a possible trend towards a suitable level of rejection. With the analysis on this basis the results and conclusions were as follows:

1. The experimental evidence gathered seemed to support the work of Rokeach[2]. It appeared that groups of individuals high on ethnocentrism were also rigid as measured by the arithmetic technique. This appears to uphold the hypothesized general mental rigidity factor.

2. The generalized mental rigidity factor probably extends to the ability to utilize the elements of the scientific method. A group of individuals characterized as non-rigid can, at the 1% level, better utilize the elements of the scientific method than a group characterized as rigid.

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[2] Loc. cit.

3. A group of subjects characterized as non-rigid was more comprehensive in its cognitive patterns than a rigid group. That, conversely, a rigid group has a cognitive pattern that is narrow. The evidence also indicated that a group measured as comprehensive in its cognitive patterns was better able to work scientific method test items.

4. There was indicated a difference, at the 10% level, between rigid and non-rigid groups in their ability to recognize a valid experiment in the laboratory. There was also indicated, at the 20% level, that the non-rigid group was better able to see causal relationships in this laboratory study. It was seen that, at the 20% level, the ability of the rigid and non-rigid groups to accept new evidence and, on the basis of this, overthrow preconceived ideas was in favor of the non-rigid group. An analysis of the results also led to the implication that the comprehensive group was better able to complete the laboratory study than the isolated or narrow groups.

It was inferred from all of the above results that, in general, the non-rigid group was better able to utilize the elements of the scientific method. It was further inferred, from the experimental evidence, that the non-rigid group was more comprehensive and less isolated and narrow in its cognitive patterns. There was

indicated a trend towards the operation of the rigid personality structure and of the comprehensive cognitive pattern in the normal classroom situation. The results seem to indicate that those individuals who are non-rigid in the thinking process and those who have a comprehensive cognitive structure are better able to do the laboratory study in the classroom.

The differences between the rigid and non-rigid groups was indicated in terms of the comprehensive and non-comprehensive cognitive structures. The rigid individuals seem to show the inability to go beyond the mere factual information at hand in their attempt to solve a problem. They react on the basis of each individual fact separately. The rigid group does not indicate the ability to see a relationship of one piece of factual information to others. The individuals of the rigid group may even simply refuse to consider some of the facts that are at their command. That the rigid individual does react in this manner is indicated in the analysis of the organizational approach used by the subjects on the interrelationships work sheet (Figure 5).

The non-rigid individual, on the other hand, has the ability to see and to state the relationships existing and necessary for the correct solution of a problem. The data gathered from the interrelationships work sheet (Figure 5) indicates that the

comprehensive group can take the individual facts under consideration and organize them into a single unified structure. The thought processes are broad and integrated and take all of the pertinent facts into consideration in arriving at a solution to a problem.

Educational implications and problems for study. The educational implications of this study and the problems growing out of them fall logically under two captions: (1) those implications and problems having to do with education in general; and (2) those implications and problems concerned specifically with the teaching of science and scientific methodology. It is with the first of these, education in general, that there is the most concern in this report. For the general educational implications and the problems arising out of them would refer to any phase of education, including that of the teaching of science and scientific methodology. Therefore, in the following discussion the emphasis will be placed primarily upon the implications of this study to education per se.

It seems almost unnecessary to state that in order to teach effectively it is essential for the teacher to be cognizant of all the factors that are motivating the efforts of the students. The teacher can be effective only in the framework of this

understanding, for the student is constantly evaluating what is presented to him by his teachers in terms of his needs, his desires, and his values. He will either reject these offerings or incorporate them into the patterns of his behavior only according as he feels their significance. It is the students own distinctive combination of needs, longings, and desires and his ways of meeting them which make up his uniqueness and which define the most effective approach to him.

To attempt to teach without this understanding of the student may lead to undesirable experiences on the part of both the teacher and the student. The data of this report indicate that the rigid-non-rigid pattern of thinking and the comprehensive-non-comprehensiveness of cognitive structure appear to be a part of the personality structure of students. Specifically, the data indicate that there is a difference in student reaction, in terms of rigidity and comprehensiveness, as concerns at least one educational objective: the teaching of the scientific method. Here, then, is a possible example of a personality factor of which teachers should be aware if desirable outcomes are to be effected in all students to the maximum degree. It can be hypothesized that if one educational objective is affected by the personality factors of rigidity and comprehensiveness, then others may also be so affected.

The educational implication in terms of teacher effectiveness, as related above, is that the teacher should be aware of the extent to which rigidity and comprehensiveness are a part of the learning situation of the student. It would seem that any learning situation which, in order to meet educational objectives, required that the mental organization be comprehensive and flexible, would have to meet the possible implications of this study: that rigidity and comprehensiveness are part of the personality structure of the student.

The treatment of symptoms, which in the case of the educator is the behavior of the student, is not enough. Just as is found so often in medicine that treatment of symptoms does not always get to the basic pathology of the disease, so in education it should be realized that symptomatic treatment of behavior does not always get to the root of the behavior, which is the personality structure. In relation to the present study not only further study of the behavioral symptoms of rigidity and comprehensiveness is necessary, but an understanding of the forces moulding and shaping the personality leading to this type of behavior is even more desirable.

This discussion is based upon the assumption that a prime educational objective is the shaping of a democratic personality.

This would mean the moulding of an individual whose personality structure is such that it will lead to those behaviors and attitudes that are considered desirable in a democracy. One of the first positive steps leading to the accomplishment of this objective would be as complete a study as is possible of the democratic personality. As one of the most universal aspects of the non-democratic personality is its rigidity of behavior and attitude, a more complete study of rigidity is in order. From the standpoint of the educator, the study of rigidity is a negative point of view—a study of what the educator does not want in the student. Therefore the positive step would be the study of the non-rigid individual. As the data of this study indicate, the non-rigid individual is also the more comprehensive in cognitive pattern. Therefore, the study of comprehensiveness of thinking in relation to democratic behavior may also be warranted.

A complete study of the rigid-non-rigid personality from the viewpoint of the educator would involve a number of interrelated aspects. These would include the child in relation to the school, the home, and the interrelationship of the school and of the home. Any study of this sort would involve both the rigid and the non-rigid individual. Again, from the viewpoint of democratic education, the emphasis should be positive, and the concentration should be on the non-rigid individual.

That there is a difference, between the rigid and non-rigid individual and between the comprehensive and non-comprehensive individual in behavior, in which the non-rigid and more comprehensive individuals appear to show a greater ability to utilize the aspects of the scientific method in the classroom, appears to be indicated by the data. Therefore, one pattern of research based upon the data of this present study would be a careful examination of the development of personality in the schools. This examination would be an effort to determine how to develop the non-rigid democratic personality. Perhaps a study of personality development in the schools contrasting an idealistic, traditional approach on the one hand, and the progressive, pragmatic approach on the other hand would answer the question of the place of the school in the development of the rigid personality. It can be hypothesized that the traditional, idealistic approach with its formalistic and paternalistic attitude to subject matter, in which the mind develops and is dependent only upon the material presented, might lead to a rigid personality. In contrast, it can be hypothesized that the progressive school, where each child is acclaimed for his uniqueness, and where each is allowed to develop without a rigid pattern imposed from above, would develop a flexible personality which would lead to the development of a non-rigid pattern of behavior

to the world about him. Studies of this type would entail careful long range planning for the subjects would have to be studied over a period of years.

A second pattern of research on rigidity of behavior concerns that of the home influence of the subjects. There is some evidence available to indicate that a rigidly prescribed home life leads to rigid behavior patterns in the adult.[3] Conversely, the non-rigid, free-acting family life may lead to non-rigid patterns of behavior. A comparative study of the home training of the individual, starting as early in the life of the individual as possible, is desirable. The research attempt here would be to study and to try to discover what type of home life, if any, is necessary to develop the non-rigid personality.

A third pattern of research would be on the effects of compatible and incompatible school-home relationships. What sort of development takes place in such atmospheres as: the non-rigid home and the rigid school; and rigid home and the non-rigid school; the rigid home and the rigid school; and the non-rigid home and the non-rigid school. This may lead to the determination of

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[3] T. W. Adorno and others, The Authoritarian Personality. (New York: Harper and Brothers, 1950) pp. 990.

the development of various degrees of rigid and non-rigid personalities.

The data of this study seem to indicate that, in the classroom situation involving a Biological Science experimental laboratory problem, the non-rigid individuals and the individuals with the comprehensive cognitive structures tend to perform better than the rigid and the non-comprehensive individuals. This would seem to indicate, as has already been stated, that rigidity plays a part in performance in the classroom and that it would therefore be desirable to formulate a study attempting to discover how to bring about a minimization of rigidity and an increased ability for comprehension. It should be recalled at this time that the available evidence, in this study and elsewhere, indicates an extremely low negative correlation between rigidity and intelligence as measured by such devices as the Stanford-Binet, the Wechsler-Bellevue, and the American Council on Education Psychological Examinations. There is also evidence which indicates that ethnocentrism shows a slight correlation with amount of education. It has not been completely demonstrated that amount of education, i.e. college, high school or less, lowers ethnocentrism. It can be said, therefore, that our present educational procedures are not reducing ethnocentrism or, in turn, rigidity.

Evidently in order to accomplish the minimization of rigidity new teaching techniques and researches should be instituted. Perhaps a good place to start would be, as suggested by Levinson,[4] the dynamics of intelligence, for there seems to be some evidence indicating a different type of intellectual functioning on the part of the ethnocentric individual, even of those of above average intelligence. This is directly in line with the proposal made in this report that a study of the democratic personality be made in all of its phases.

The methods suggested in the "Authoritarian Personality"[5] for change of a rigid personality to a non-rigid personality all seem to revolve about individual psycho-therapy. But it is admitted that in terms of cost, time, and available personnel this idea is not feasible. The contributions from this source would be almost negligible because it is an individual method, and in the school situation there is concern with large groups of individuals. Therefore, study is needed in order to determine whether it is possible to adapt the individual psycho-therapeutic measures for use upon large groups of individuals. A trite statement may be

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[4] Ibid., p. 287.

[5] Ibid., pp. 974-975.

added here: that as far as the educator is concerned, it is probably worth far more to adopt a policy of "prevention" than one of "cure," for it seems at the moment as though the task ahead is long and arduous—the task of minimization of rigidity once this type of personality has been formed.

The present investigation represents, as far as could be ascertained, the first attempt to relate the concept of rigidity to a specific educational objective: the teaching of the scientific method. This report, as can be seen, is merely a preliminary and opening phase attempting to show that a factor of the personality—the hypothesized generalized mental rigidity—may be a major problem to be faced in the education of the democratic citizen.

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APPENDICES

APPENDIX A

Date_____ Sex_____ Date of Birth_____

Race or national extraction_____ Religion_____
City and State of birth_____

This is a study of what the general public thinks and feels about a number of important social questions. The best answer to each statement below is your personal opinion. We have tried to cover many different points of view; you may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others; whether you agree or disagree with any statement, you can be sure that many other people feel the same way that you do.

Mark each statement in the left margin according to how much you agree or disagree with it. Please mark every one. Write in + 1, + 2, or + 3; or − 1, − 2, or − 3, depending on how you feel in each case.

+ 1: I AGREE A LITTLE	− 1: I DISAGREE A LITTLE
+ 2: I AGREE PRETTY MUCH	− 2: I DISAGREE PRETTY MUCH
+ 3: I AGREE VERY MUCH	− 3: I DISAGREE VERY MUCH

____ 1. Zootsuiters prove that when people of their type have too much money and freedom, they just take advantage and cause trouble.

____2. Negroes have their rights, but it is best to keep them in their own districts and schools and to prevent too much contact with Whites.

____3. Labor unions should become stronger and have more influence generally.

____4. One trouble with Jewish business men is that they stick together and prevent other people from having a fair chance in competition.

____5. The worst danger to real Americanism during the last 50 years has come from foreign ideas and agitators.

____6. America may not be perfect, but the American Way has brought us about as close as human beings can get to a perfect society.

____7. I can hardly imagine myself marrying a Jew.

____8. It would be a mistake ever to have Negroes for foremen and leaders over Whites.

____9. Most government controls over business should be continued even though the war is over.

____10. There may be a few exceptions, but in general, Jews are pretty much alike.

____11. If Negroes live poorly, it's mainly because they are naturally lazy, ignorant and without self-control.

____12. Men like Henry Ford or J. P. Morgan, who overcame all competition on the road to success, are models for all young people to admire and imitate.

____13. The trouble with letting Jews into a nice neighborhood is that they gradually give it a typical Jewish atmosphere.

____14. If and when a new world organization is set up, America must be sure that she loses none of her independence and complete power in matters that affect this country.

____15. In general, full economic security is bad; most men wouldn't work if they didn't need the money for eating and living.

APPENDIX B

1. Recognition of a logical hypothesis.

   (a) Application of heat to a wound will hasten clotting. The most logical hypothesis, based on information gained in the course, would be that
   1. the heat causes the blood to thicken, and so hastens clotting.
   2. the heat causes the red blood cells to clump.
   3. the heat brings about the breakdown of platelets which in turn releases thrombokinase.
   4. the heat brings about the breakdown of the white blood cells which release a clotting agent into the blood stream.
   5. none of the above could be considered a logical hypothesis.

   (#3 is the key answer)

   (b) From Carlson and Johnson, page 347.

   "Our first clue as to how the kidney works comes from anatomy—from a careful consideration of the structure of a Bowman capsule and its relationship to the glomerulus. Here we have capillaries in close apposition to a membrane made up of thin flat cells, quite unlike secretory cells in structure. The walls of the capsule closely resemble the thin walls of the capillaries themselves and also of the lung."

   On the basis of these observations and knowledge gained in the course, which of the following hypotheses is the most logical?
   1. Blood waste materials pass from circulatory system to urinary system by osmosis.
   2. The glomerulus probably acts like a secretory gland in order to remove circulatory waste materials.
   3. Bowman's capsule must secrete waste materials.
   4. Blood waste material passes from glomerulus to Bowman's capsule by filtration.
   5. Blood waste material passes from Bowman's capsule to glomerulus by filtration.

   (#4 is the key answer)

The following concerns items C and D.

Analyses made on the blood of thousands of people before and after exercise show that after exercise there is a decrease in the oxygen, and an increase in carbon dioxide and in lactic acid. The rate and depth of breathing increases during exercise.

PROBLEM: To determine the stimulus for an increased rate and depth of breathing.

The following items were suggested as hypotheses to be used as a basis for experimentation to solve the problem. Evaluate them according to the following key.

Key

1. Logical hypothesis.
2. Illogical hypothesis because it is unrelated to the problem.
3. An explanation in terms of purpose.
4. Illogical hypothesis because it contradicts the data.
5. Not an hypothesis.

(c) A change in the concentration of some of the chemical substances carried by the blood is the stimulus for increased rate and depth of breathing.

(#1 is the key answer)

(d) A decrease in oxygen is the stimulus for increased breathing.

(#1 is the key answer)

2. Recognition of the best hypothesis.

Two of the antigens present in the blood are M and N. These two form blood types MN, M, and N, and are found in 50%, 30% and 20% of the population respectively. In humans, no reaction occurs in transfusing and mixing of these blood types. Of the hypotheses below, which is the best concerning the formation of antibodies of M, N, and $\overline{MN}$ in man?

1. All three form antibodies.
2. Antibodies of MN are formed.
3. Antibodies of M are formed.

4. Antibodies of N are formed.
5. No antibodies are formed.

(#5 is the key answer)

3. Recognition of a statement that is not an hypothesis.

Analyses made on the blood of thousands of people before and after exercise show that after exercise there is a decrease in the oxygen, and an increase in carbon dioxide and in lactic acid. The rate and depth of breathing increases during exercise.

PROBLEM: To determine the stimulus for an increased rate and depth of breathing.

The following items were suggested as hypotheses to be used as a basis for experimentation to solve the problem. Evaluate them according to the following key.

Key

1. Logical hypothesis.
2. Illogical hypothesis because it contradicts the data.
3. Illogical hypothesis because it is unrelated to the problem.
4. An explanation in terms of purpose.
5. Not an hypothesis.

(a) The concentration of oxygen is decreased and the concentration of carbon dioxide is increased during exercise.

(#5 is the key answer)

(b) Exercise increases the heart rate.

(#5 is the key answer)

4. Recognition of an illogical hypothesis because it contradicts the data.

Refer to problem and answer key in number 3 using the following:

A lack of carbon dioxide is the stimulus for an increase in rate and depth of breathing.

(#2 is the key answer)

5. Recognition of data contradicting an hypothesis.

One characteristic of cancer is continued proliferation or division of cells.

Removal of the ovaries of a strain of mice showing a very high susceptibility to mammary gland cancer caused a marked reduction in the incidence of the disease.

Mammary gland cancer was produced in male mice, which ordinarily are not susceptible to the disease, by injection of large doses of female hormone.

On the basis of the above data one might make the following hypothesis:

Some types of cancer may be caused by certain hormones, possibly as yet unknown, which tend to stimulate cell division.

Use the following key to evaluate the way in which the following statements may be related to the hypothesis above.

Key

Mark space "1" if statement supports the hypothesis.
Mark space "2" if statement is unrelated to the hypothesis.
Mark space "3" if statement contradicts the hypothesis.

The effect of the "juvenile hormone" of insects which inhibits the development of adult characteristics.

(#3 is the key answer)

6. Recognition of data supporting an hypothesis.
Refer to problem and answer key in number 5.
The effect of progesterone on the uterine wall.

(#1 is the key answer)

7. Recognition of data unrelated to the hypothesis.
Refer to problem and answer key in number 5.
The effect of the hormone from the adrenal medulla.

(#2 is the key answer)

8. Recognition of a principle.
Use the following key:

Key

Mark space "1" if the statement represents a problem.
Mark space "2" if the statement represents an observation.
Mark space "3" if the statement represents an hypothesis.
Mark space "4" if the statement represents a principle.
Mark space "5" if the statement represents none of the above.

(a) Metabolic processes are carried on in the presence of enzymes, organic catalysts, which are manufactured by the organism and are present in every cell.
(b) Life is dependent upon an external source of energy.

(#4 is the key answer to a and b)

9. Recognition of a valid experiment.

The following experimental procedure would be of little value in determining if an organ is an endocrine gland.
1. Extracting hormone from the gland.
2. Removal of the gland.
3. Chemical analysis and synthesis of the substance produced by the gland.
4. Administration of hormone artificially.
5. Extracting hormone from the blood.

(#3 is the key answer)

10. Recognition of the results of an experiment.

A resting (without stimulation) spinal nerve was found to yield 2 calories of heat for a given period of time. When the same nerve was stimulated 1000 times per second it yielded 5 calories of heat for the same period. Among other things these results indicate that
1. The surrounding tissues provide the heat given off by nerve fibers.
2. Resting neurones carry on respiration.
3. The heat given off by resting neurones is easily measured.
4. During conduction neurones carry on respiration but not during rest.

5. Only the fibers of neurones give off heat.

(#2 is the key answer)

11. Recognition of the probability factor in an experiment.

(a) Assume that brown (B) eye color is completely dominant over blue (b) eye color. Two heterozygous brown eyed parents have produced three brown eyed boys. Which of the following is the most accurate statement regarding the possibility of their next child having blue eyes?

1. It is likely to have blue eyes since the three boys already have brown eyes.
2. Chances for blue eyes cannot be determined because both parents are heterozygous.
3. One chance in four that it will have blue eyes.
4. One chance in three that it will have blue eyes.
5. Chances are equal (1:1) that it will have blue eyes.

(#1 is the key answer)

(b) In flies, long wing is dominant over short wing and grey body is dominant to black body. A number of crosses were made between flies, all of which were hybrid for both wing length and body color. Three hundred and twenty (320) offspring were produced of which twenty-three had short wings and black bodies. Which of the following is correct?

1. Approximately 297 of the flies were long-winged and grey-bodied.
2. There should have been at least eighty flies with long wings and black bodies.
3. About one-third of the flies were long-winged and grey-bodied.
4. The number of flies homozygous for both characters is somewhat greater than the theoretical expectancy.
5. One-ninth of the flies were grey-bodied with long wings.

(#4 is the key answer)

(c) A man and wife had seven children, four brown eyed, and three blue eyed. On the basis of this which of the following could be true?

1. Neither the man nor the woman had blue eyes.
2. The man was heterozygous and the wife homozygous.
3. All of the brown eyed children were heterozygous.
4. The mother was of the same genotype as the father.
5. All of the above could be true.

(#5 is the key answer)

12. Recognition of causal relationships.

(a) Select from below the best explanation as to the manner in which a and b are related.

1. A causal relationship exists—a causes b.
2. Both a and b are false statements.
3. A contradicts b—if a is true, b is false.
4. A and b are both true statements, but no relationship exists.
5. A and b share a common cause—both are the result of the same mechanism.

(#5 is the key answer)

(b) This item concerns human reproduction. In which instance below is the second part of the statement the direct result of the first part?

1. The uterine lining develops; progestrone is produced.
2. The pituitary gland secretes a hormone; a follicle produces an egg.
3. A follicle develops; FSH is produced.
4. Estrin is produced; a follicle of the ovary develops.
5. The corpus luteum develops; estrin is produced.

(#2 is the key answer)

(c) Indicate by blackening the appropriate space which statement listed below is not the cause or any part of the cause of the turning of plant stems toward light.

1. The light intensity may be unequal in different plant parts.
2. The plant needs more light.
3. Auxins stimulate cellular elongation.
4. The effect of auxins is inhibited by light.
5. There is an unequal elongation of cells.

(#2 is the key answer)

13. Recognition of a statement warranted by all or part of the data given.
Read the following descriptions of experiments.

Experiment A. The pituitary gland was removed from a number of rats. Subsequent to recovery many parts of the reproductive system became much reduced in size and ability to function. Operations on other rats which were similar in every respect except that the pituitary was left intact had no such results.

Experiment B. Rats from which the pituitary had been removed were given injections of pituitary extract. The reproductive systems of these rats were returned to normal (temporarily).

Experiment C. A number of immature female rats were given injections of pituitary substance. Whole pituitary glands were transplanted into other immatures. All of these immature females developed reproductive organs typical of normal adults.

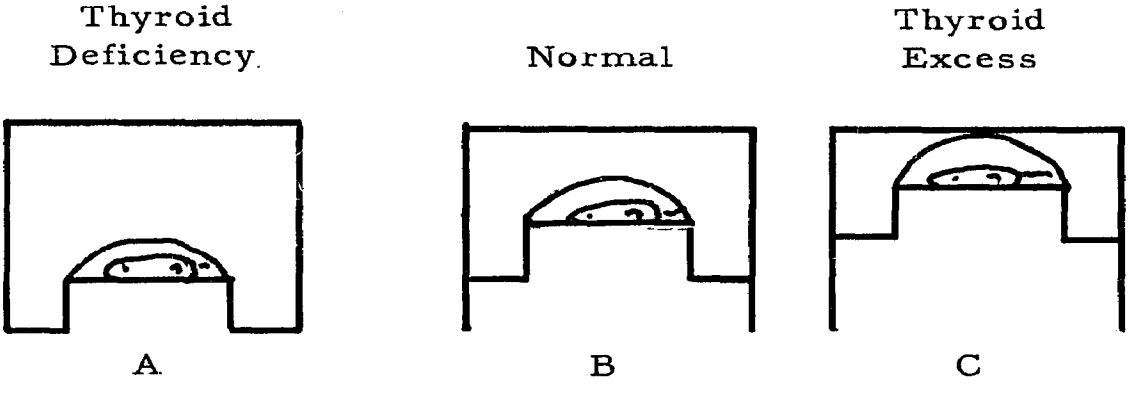
Experiment D. The pituitary gland was removed from a number of rats. Then each of these rats was surgically connected to a normal rat so as to produce a number of "Siamese Twins" (technically known as Parabiotics). Subsequent to recovery, blood test showed large (practically normal) quantities of pituitary substance present in both animals of each parabiotic pair.

For each item blacken:
Space 1 if the statement goes beyond the inference to be drawn from the preceding experiments.
Space 2 if it is warranted by all or by part of the data given.
Space 3 if it is contradicted in whole or in part by inferences based on one or more of the experiments.

The pituitary gland of the average rat is apparently capable of producing more pituitary substance than is required by the average rat.

(#2 is the key answer)

14. Recognition of a statement contradicted by the data.



Each of the three chambers is so arranged that, as oxygen is used up by the rat within, the platform upon which the rat rests rises in the oxygen filled chamber. Each rat is retained in a small wire cage to reduce muscular movements and therefore approximate "basal" metabolic conditions. Note that the rat with thyroid deficiency (thyroid gland removed) uses less oxygen than the normal, and that the rat with thyroid excess (from feeding thyroid hormone) uses more oxygen than the control animal in chamber B. All three chambers were at the same height at the start of the experiment and all rats weighed the same. From the film "The Endocrine Glands."

Assuming that the data given are correct than on the basis of these facts and your knowledge of their implications consider each statement below.

Mark space 1 for each statement which is a reasonable interpretation of the data given.
Mark space 2 for every statement which "might be" true or false, but for which the data given are insufficient to warrant the statement being marked 1 or 2.
Mark space 3 for every statement which cannot be true because it is contradicted by the data given.

During this experiment the mouse in container A probably eliminated more CO_2 than the mouse in chamber C in the same length of time.

(#3 is the key answer)

15. Recognition of a reasonable interpretation of the data.
(a) Refer to problem and answer key in number 14.

The stimulus provided by the thyroxin hormone is the cause of the increased use of oxygen by the mouse in chamber C.

(#1 is the key answer)

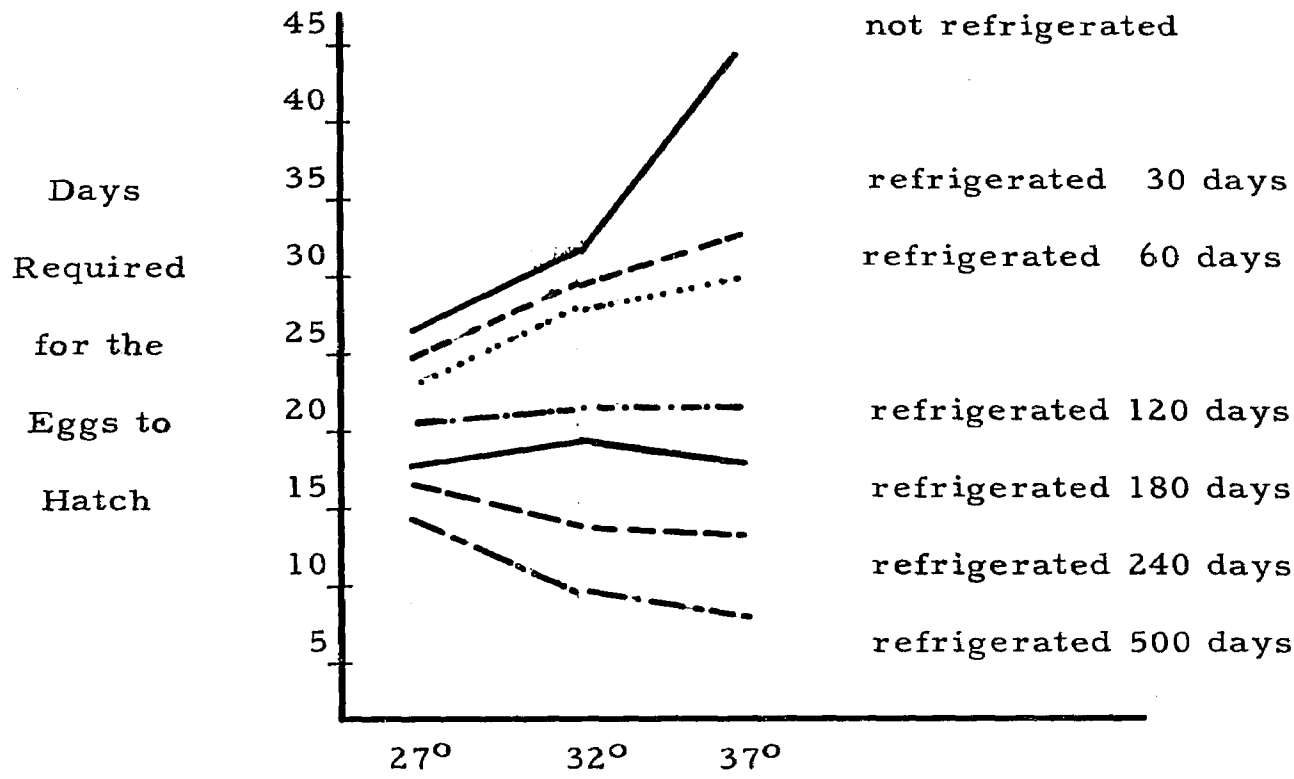
For b and c use the following data.

Several groups of eggs of the grasshopper Melanoplus maxicanus were taken immediately after they were laid and placed in a refrigerator at 0° C. The different groups of eggs were refrigerated for different lengths of time, and then, incubated until hatched. Each group of eggs after refrigeration was divided into three lots, and each lot was incubated at a different temperature (27°, 32°, and 37° C.). The graph below shows the time required for incubation in these various batches of eggs. (Data from Uvarcv, 1931, Insects and Climate, p. 35.)

Assuming the data given are correct, then on the basis of these facts and your knowledge of their implications consider each statement on the opposite page.

Key

Mark space 1 for each statement which cannot be true because it is contradicted by the data given.
Mark space 2 for each statement which is a reasonable interpretation of the data given.
Mark space 3 for each statement which "might be true or false" but for which the data given are insufficient to warrant the statement being marked 1 or 2.



B and c are to be answered on the basis of the data and graph presented.

(b) Refrigerating these eggs at 0° C. after they are laid results in an acceleration of their development, when they are incubated at temperatures from 27° to 37° C.

(#2 is the key answer)

(c) When these eggs are kept at 0° for two months before they are incubated, the "best temperature" for their development (between 27° and 37°) will be lower than it would be when the eggs are kept at 0° for eight months before they are incubated. (Best temperature for development means the temperature at which hatching occurs in shortest time.)

(#2 is the key answer)

16. Recognition of data insufficient to warrant a statement in any direction.

(For a and b items refer to problem and answer key in 14.)

(a) This experiment proves that the thyroxin hormone is the only stimulus resulting in an increased metabolic rate.

(#2 is the key answer)

(b) If the amount of thyroxin hormone fed to the mouse in container C had been doubled this mouse would have used the oxygen present in chamber C in half the time.

(#2 is the key answer)

(c) (For this item refer to the problem and key in 15.)

A greater proportion of the eggs of this grasshopper will hatch if they are incubated immediately after they are laid, than if they are refrigerated before being incubated.

(#3 is the key answer)

17. Recognition of statements going beyond the inferences to be drawn from experimentation.
For items a and b use the following data.

Experiment A. The pituitary gland was removed from a number of rats. Subsequent to recovery many parts of the reproductive system became much reduced in size and ability to function. Operations on other rats which were similar in every respect except that the pituitary was left intact had no such results.

Experiment B. Rats from which the pituitary had been removed were given injections of pituitary extract. The reproductive systems of these rats were returned to normal (temporarily).

Experiment C. A number of immature female rats were given injections of pituitary substance. Whole pituitary glands were transplanted into other immatures. All of

these immature females developed reproductive organs typical of normal adults.

Experiment D. The pituitary gland was removed from a number of rats. Then each of these rats was surgically connected to a normal rat so as to produce a number of "Siamese Twins" (technically known as Parabiotics). Subsequent to recovery, blood test showed large (practically normal) quantities of pituitary substance present in both animals of each parabiotic pair.

Space 1 if the statement is warranted by all or by part of the data given.
Space 2 if it is contradicted in whole or in part by inferences based on one or more of the experiments.
Space 3 if it goes beyond the inference to be drawn from the preceding experiments.

(a) Castration (i.e., removal of the testis in the males or ovaries in the females) results in degeneration of the reproductive system.

(#3 is the key answer)

(b) Injection of pituitary substance into a senile rat (aged beyond the normal reproductive period) will cause the reproductive system to become (temporarily) functional again.

(#3 is the key answer)

18. Recognition of a statement contradicted in whole or part by inferences based on one or more experiments. For items a and b refer to problem and key in 17.

(a) Sexual immaturity is probably due to the fact that during immaturity the reproductive system is unable to respond to the effects of pituitary substance.

(#2 is the key answer)

(b) Surgical shock involved in operations on the head is apparently sufficient to cause degeneration of the reproductive system.

(#2 is the key answer)

APPENDIX C

Study 14[1]

ADJUSTMENT AND COORDINATION IN PLANTS

There are certain areas in science where the thinking and experimental processes have been so clear and concise that they have become classics. In the physical sciences such classics can be found in the work of Gallileo on falling bodies, Kepler in astronomy, and Lavoisier in chemistry. In biology, classics of this sort can be found in the works of Claude Bernard on physiology, Pasteur on fermentations, and Mendel on heredity. In this century some of the work on hormones has been of this type and will probably become classical as time passes.

Our problem today deals with a series of rather simple experiments whose results can be used in the formulation, testing, and modification of hypotheses. The experiments are so chosen that the mentally active student will take delight in the orderly procession of thought that he finds he is capable of developing as the problem progresses.

Although the work in this Study deals with plants, the pattern of thought and of procedure has been and is being applied with great success in all kinds of organisms, both plant and animal. Also, the method of adjustment and coordination which becomes evident is common to both plants and animals. In animals this type of coordination and adjustment is much more highly developed and much more complicated. Thus, the study of plant reactions lays a sound and simple basis for understanding the more complex situations found in animals.

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[1] Department of Biological Science, Guide for Laboratory Studies in Biological Science (East Lansing, Michigan State College Press, 1949), pp. 137-144.

PROBLEM 1

What is a mechanism for adjustment to the environment in higher green plants?

You may have observed evidences of adjustment in plants, for example, the bending of plants toward light. List two other evidences of adjustment in plants. _____

_____

What do you think is the mechanism that causes plants to turn toward the light? _____

In the following experiments groups of oat seedlings have been used as the experimental material. The results were the same for all plants in each group, so only one plant from each group will be described. In the first four experiments the plants were grown in the dark.

The tip of a stem contains meristem tissue which is composed of dividing cells. The region below the tip is the region of elongation where cells elongate but do not divide. In the following Experiments there was no increase in length of the meristem tips because the duration of each experiment was only a few hours.

Experiment 1

Three oat seedlings of the same size (A, B, and C) were used for this experiment. All plants in Experiments 1, 2, 3, and 4 were grown in the dark. Plant A was allowed to grow normally. The tip of meristem tissue was cut off of plant B. The tip was then replaced on the cut surface of the plant. The tip was cut off of plant C and was discarded. Draw a diagram to illustrate the shoots of the three plants. Exaggerate the thickness of the stem, making it at least one-fourth inch. Draw a line to indicate the position of the cut on B.

A B C

Why was plant A included in the experiment? _____

Results

Plant A grew normally and when the experiment was terminated it was one-third taller than it had been at the beginning of the experiment. Plant B was only slightly shorter than A. Plant C was the same height as it was at the beginning of the experiment. Draw diagrams of the shoots of the plants as they were at the end of the experiment beside the first drawings.

Conclusions

Was some stimulation from the tip necessary for elongation of the stem? _____

On which phase of the experiment do you base your answer? Explain. _____

Could there be any direct structural connection, such as nerves, between the tip and the elongating portion of the stem? _____

How do you know? _____

Make an hypothesis which would explain the results of this experiment. _____

Experiment 2

Three more oat seedlings again designated A, B, and C, were used in this experiment. Plant A was allowed to grow normally. The tip was cut off plant B and a one mm. thick block of agar (a material through which substance can diffuse) was placed on the top of the cut stem. The tip was placed on top of the agar. The tip was also removed from plant C. A thin sheet of mica (a substance which prevents diffusion) was placed between the stem and the tip. Draw diagrams to illustrate the experiment. Indicate the position of the agar and of the mica.

A B C

Results

Plant A grew normally. The stem of plant B also grew normally. Plant C did not grow. Draw diagrams to show what happened in Experiment 2.

Conclusions

Do the results of this experiment confirm the hypothesis you made from the data of Experiment 1? _____

Did you omit anything in your original inference which could now be added as a result of this experiment? _____

Restate your hypothesis in the light of the new facts. _____

_____

_____

What were the controls for this experiment? _____

_____

List two other possible explanations of the results of these experiments. _____

_____

Experiment 3

The juice was extracted from tips of oat seedlings and this juice was mixed with agar and small agar blocks were made. Blocks were also made of plain agar. Three groups of oat plants were again used; A, B, and C. Plant A was untreated. A block of agar containing juice from growing tips was put on top of the stem of plant B, which had had the tip removed. A plain agar block without the juice of the tips was placed on top of the stem of plant C, which also had the tip removed. Illustrate the procedure with diagrams.

A B C

_____

Results

Plant A grew normally. Plant B also grew normally. Plant C did not grow at all. Diagram the results.

Conclusions

Do the results of this experiment eliminate some of the possible explanations for the results of Experiments 1 and 2?

_____. Why? _____

_____

Is your original hypothesis now on a higher level? _____

What is meant by an hypothesis being on a "higher level"? _____

If your original hypothesis or your second revision of it was incorrect or incomplete, revise it.

Why was a plain agar block used on one of the plants?

Experiment 4

Three plants (A, B, and C) were used for this experiment. Plant A was allowed to grow normally. The tips were removed from plants B and C. A block of agar mixed with juice from growing tips was placed on the left half of the cut surface of the stump of plant B, and a piece of agar treated in the same way was placed on the right half of the stump of plant C. Draw a diagram to illustrate the procedure. Check with your instructor to make sure your pictures are correct.

A B C

Results

Plant A grew normally. Plant B curved to the right, whereas plant C curved to the left. Draw diagrams to show the results.

Conclusions

What are the two controls for this experiment?

Where did growth (elongation of cells) take place in B? _____

_____. In C? _____

Where did the growth stimulation come from? _____

_____

Why did only one side grow? _____

Restate your last hypothesis making it more specific. _____

_____

On the basis of this last experiment can you make a tentative explanation of the bending of plants towards the light? _____

_____

Experiment 5

Three plants, A, B, and C, were used. Plant A was allowed to grow normally. A piece of mica was inserted between the growing tip and the rest of the stem on the left side of plant B, and a piece of mica was inserted into the right side of plant C. The tips of all three plants were illuminated from the right side only. Draw diagrams to show the procedure, including the source of light.

A B C

_____

Results

Plants A and C bent to the right, but plant B did not bend or grow. Draw diagrams to show the results. Be sure to indicate the position of the mica and the source of the light. Note: The amount of light used has no direct effect on the elongating cells.

Conclusions

Recall the results of the previous experiments. What caused elongation? _____

_____

Under what conditions of illumination were the other experiments performed? _____

What is the apparent effect of light? _____

_____

Why does elongation take place on one side only? _____

_____

Why did plant B fail to curve? _____

_____

Was growth substance produced in the tip of the left side of plant B? _____

Why did this growth substance fail to cause elongation of the cells of the left side of plant B? _____

_____

Was your hypothesis as to why plants bend toward light correct? _____. If not, revise it. _____

_____

_____

Conclusions Based on All Five Experiments

Make a general statement which will answer the original question; what is a mechanism for adjustment to the environment in plants? Be sure to interrelate all of the factors illustrated by these experiments. _____

_____

Questions

1. Do plants grow more in the daytime or at night? _____ On what do you base your answer? _____

_____

2. Give an explanation for the bending of a stem upward when a potted plant is turned on its side. _____

_____

3. From your general knowledge of the requirements for growth what factors beside sunlight might affect the rate of growth of plants in the daytime? _____