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## Preliminary Study of a Test of Inductive Reasoning in the Upper Grades

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PRELIMINARY STUDY OF A TEST  
OF INDUCTIVE REASONING  
IN THE UPPER GRADES

by

Sister Mary Colomana Buksa, C.S.S.F.

A Thesis Submitted to the Faculty of the Graduate School  
of Loyola University in Partial Fulfillment of  
The Requirements for the degree of  
Master of Arts

June  
1960

## LIFE

Sister Mary Colomana Buksa, C.S.S.F., was born in Chicago, Illinois.

She was graduated from Good Counsel High School, Chicago, Illinois, attended DePaul University, Chicago, Illinois, and received her degree of Bachelor of Science in Education from Loyola University, Chicago, Illinois, where she pursued further studies in psychology.

The writer has been engaged as a teacher in the various schools conducted by the Felician Sisters.

### ACKNOWLEDGMENT

The writer gratefully acknowledges her indebtedness to Reverend Charles I. Doyle, S.J., for his encouragement and help, in the development and completion of this study. It was through his inspiration that this study was undertaken.

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## CHAPTER I

### INTRODUCTION: STATEMENT OF THE PROBLEM

Number-series problems were being developed for testing purposes early in the twentieth century. It was hoped that by means of tests of this type it would be possible to tap the mental process of induction by measuring and analyzing abilities involved in high school mathematics. The purpose of the present study is to determine the effectiveness of a number-series test in discovering differences in inductive reasoning among children at different levels in the four upper grades.

The fundamental psychology underlying all thinking is well illustrated by inductive reasoning, which is the psychological process of passing from the observation of particular instances to a general truth or law. It is the detecting of similarity within diversity, yet it is more than a mere summarizing of observed similarities. The generalization made in inductive reasoning may embrace an indefinite number of unknown cases along with the known and because of this universal grasp it becomes universally comprehensive and serves its subsequent purpose as a principle of reasoning. (7)

It would appear that a process like inductive reasoning seems to begin in the cradle. To every infant the world is an enormous puzzle, a field of perplexity constantly testing his ingenuity. There is endless variety and complexity confronting him. In acquiring knowledge inductively the infant looks at the world which he visualizes as a mass of confusion. It is waiting for the operation of his curious, inquisitive mind, and he attempts to isolate the parts and reconstruct them into an understandable whole.

The process of induction calls for such mental activities as sensation, perception, conceptualizing, generalization, comparison, analysis and synthesis (or reasoning). The process of induction leads the mind through a whole series of these acts.

By natural process a child observes different objects, compares and groups similar objects together, and forms a general notion in a more or less regular process of induction. As soon as a child begins to recognize and name new objects because of their resemblance to things previously seen, the process of concept building is manifest. The mind of a child is very active in detecting resemblances and grouping similar objects together. This work of observing, comparing, and classifying is almost a constant operation in a child's mind. In this way what appeared



at first as a complete confusion begins to fall into groups and classes with appropriate names. This tendency to classify is spontaneous and natural and almost unconscious and results in a better understanding and interpretation of things around him. (2)

Recent empirical studies of this ability have been in factor analysis of the different activities of the mind which may be determined and measured by means of inductive thinking. These have brought to mind questions centered about several points, namely: Is inductive reasoning a static thing or a functional, dynamic process within the total personality? If it is subject to training and maturation, does it become significant and conspicuous at any particular age level or does it exhibit consistent, progressive development from one age level to another? If it is a gradual growth, can change in inductive ability as such be measured?

Fox (2, p. 346) says, "Since it is more concrete, inductive reasoning is often simpler for a child, and in its elementary forms, such an elimination of hypothesis is well within the competence of a child of eight years." Thorndike asserts that intelligence is affirmed by such processes as analysis, synthesis, and organization of material. Another author of the nineteenth century states,

In younger children the inductive process presents itself as a very crude form at first and only attains to a more perfect form with intellectual development and with the discipline supplied by education. (7)

In another place he says,

Again the development of inductive process involves a transition from impulsive, hasty generalizations to a more reflective and cautious type. At the outset the child is disposed to expect too much similarity in things and he will often generalize from an absurdly inadequate range of observation . . . As experience widens and intelligence advances he begins to note the points of diversity as well as those of uniformity in events, to make a more expended examination on instances, and to take some pains to limit his conclusions. (7)

Herbart called induction the mental act of breathing because of the constancy of the mind's movement. The inductive process is principally founded on association of ideas indicating clearly the natural trend of mental elaboration and on the basis of resemblance. When cause and effect are perceived between objects and series they are easily retained in memory.

Logical concepts include all the common characteristics of the group and exclude all that is not essential. They are a product of accurate and mature thinking. They are the final outcome of comparison and reasoning toward conclusion. Induction is a natural, psychological method of acquiring and unifying knowledge in an interesting way. It is understanding the "whole thing" in its parts and connections.

In this present study we wish to determine whether differences in inductive reasoning ability exist between grade

levels: (1) if they do, are they significant; (2) is there a consistent increase from one level to another; (3) to what extent is it genetically and environmentally determined; (4) how may it be investigated experimentally?

## CHAPTER II

### REVIEW OF RELATED LITERATURE

Experimental investigations in the field of induction are comparatively new. Aristotle mentioned induction, but confined his discussion of it to those cases in which the examined instances are known to be all the instances -- what is known as pure induction. Francis Bacon is popularly called "father of modern induction." He gave a set of rules by means of which he thought that the examination of past instances could lead to a virtually certain generalization. Copernicus, Newton, and Darwin are classed among the inductive scientists because they set forth some basic generalizations in an attempt to describe the operations of nature.

For centuries the great thinkers stood in awe and admiration of the human power to think and reason. Philosophers tried to define it and psychologists constructed tests to measure the individual's capacity or ability to reason. Many of these tests were designed by persons with widely varying theories and notions of intelligence. Some workers in the field, relatively unconcerned with the ultimate or theoretical meaning

of intelligence, have concerned themselves chiefly with the construction and analysis of tests, but we owe it to Spearman for providing a philosophical background against which to evaluate any test and which may be illustrated by the searching analysis of tests. According to Spearman, the nature of intelligence can only be adequately discussed when the principles of cognition have been set forth; for whatever else intelligence may involve, it is undoubtedly primarily a cognitive function. In his acute analysis of cognition, he set up three principles describing thinking in empirical terms. Thinking occurs on the basis of experience, which is acquired largely by means of sensation, the process whereby this material world passes into "mind." Thinking itself manifests three qualitative principles which he states as follows:

1. Apprehension of experience: Any lived experience tends to evoke immediately a knowing of its characters and experienter. (6, p. 48).
2. Eduction of relations: The mentally presenting of two or more characters (simple or complex) tends to evoke immediately a knowing of relations between them. (6, p. 63).
3. Eduction of correlates: The presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character. (6, p. 91).

The number series are cited by Fox (2) as a good example of Spearman's third principle. "Any number series illustrates the same principle; e.g. given the series, 2,4,8,16,

32, —,—,—, it is obvious that the relations between these fundamentals is that of geometric progression, and, therefore the succeeding fundamentals are determined." (2, p. 284).

It appears that Agnes Low Rogers was first to employ the number series in her sextet of tests, entitled "Experimental Tests of Mathematical Ability and Their Prognostic Value," with the hope that it would give some indication of the pupil's ability to analyze numerical or symbolic data, to perceive a general rule implicit in them, and to apply the principles so derived. The table of correlations for the two schools she used for the two applications of the test indicate a reliability coefficient of .75 and .70 for the two applications of the test for the two schools respectively, and .86 and .82 as the reliability coefficient for the two applications of the tests combined for the two schools, with a probable error of .08 and .07. (5, pp. 43-46).

Her test consisted of twelve items, each having four numbers and one empty space in the middle. The four common processes were involved. The study was primarily directed to discover dynamic and quantitative relations between mathematical abilities, rather than to show how to think in mathematics, also to determine the fundamental relations between mathematical abilities and their connections with certain other mental abilities. (5)

Similar to this test is the Interpolation Test used in the same sextet of tests. It is made up of forty items of varying lengths; the first having two empty spaces and the last ten, e.g. 7 \_ \_ \_ \_ 31 \_ \_ \_ \_ 55. The missing numbers are supplied by addition. The reliability coefficient for two applications of the test was .71 for the one school and .94 for the second. For the two Rogers tests combined the coefficient of correlation was .83 for one school and .97 for the other, with a probable error of .07 and .06. (5, pp. 43-46).

These tests by Rogers were later revised by F.L. Wells and his associates, and the results were used for the establishment of Test 6 in the Army Alpha, for testing recruits and draftees during the First World War. The Army experimented a long time on the number series before it was adopted as part of the Army test. The inductive reasoning test among other tests ranked first or second in the rank order of correlations.

Among Thurstone's many important contributions to mental measurement have been a development of the theory of primary mental abilities and the construction of tests to measure these abilities.

In 1932 L.L. Thurstone and his associates began an exhaustive study which led to the description of at least eight separate mental abilities. One of these abilities which he names and which he describes as inductive reasoning, represents

the ability to solve logical problems, to foresee, and to plan. This is said to be the most important of the mental abilities. To tap this ability Thurstone developed a number series, a letter series, and a letter grouping test. The reasoning factor is involved in tasks that require the subject to discover a rule or a principle covering the material of the test. Thurstone found the number series heavily saturated with the inductive factor. (18) The SRA Primary Mental Abilities, Grades 9-12, contains thirty-three number series items varying in length. Reliabilities and inter-correlations on these tests were computed by the Spearman-Brown method for 500 students in grade 10-B; the reliability for reasoning being .93. These number series are also used at different levels of the SRA PMA tests with high correlations.

G.B. Baldwin compiled a forty-item series completion test in 1949. This test is a part of the "Planning for Life" series intended for high school use for screening students for mathematics classes. The test includes such complex series as progressive division and the recognition of series of prime numbers. The items are scaled and arranged in order of difficulty.

In his directions for administering the test, Baldwin states that inductive reasoning is the ability required to a high degree in solving mathematical formulas and in breaking codes. It is a fundamental process in all research.



In the present experimental study the number series test was used to secure some information on its effectiveness in discriminating growth and development of the inductive factor in children at the upper grade levels.

## CHAPTER III

### PROCEDURE

The Loyola Induction Study used as test material in this experiment was a newly compiled number series test consisting of forty-two items of estimated difficulty. Each series was made up of six numbers and three empty spaces. Two very simple examples, to be worked out jointly by the administrator and the subjects, were placed in the directions for administration. The test was administered to each group according to special instructions. (See Appendix for a copy of the test and the instructions).

In order to secure a good sample of population, the subjects of this study were 400 children from grades five through eight from three parish and two public schools in different sections of Chicago. Two hundred and twelve were girls and 188 were boys, each grade being of heterogeneous grouping, consisting of poor, average, and superior pupils. The children were tested in their own classrooms and the examiner used the same directions and method of procedure with each group in the

parish schools. The administration of the test in the public schools was under the supervision of an experienced teacher, who used the same directions and instructions.

To eliminate tension and to obtain full cooperation, the children were told that this is not a school test where they could "fail" and that it would have no bearing on their school grades. They were further told that they were helping in a research project conducted by Loyola University. In this way the conditions of administration were uniform in all schools. The subjects cooperated fully.

Subjects were first allowed ten minutes to complete as many problems as they could. They were then told to draw a line under the series they have just completed and then continue to work until they were told to stop. Twenty minutes were allotted in all. It was arbitrarily decided that in this time the best of the subjects could scarcely complete the test successfully. In the final scoring no attention was paid to the number of items completed in the first ten minutes, but the complete test was considered. The time factor could have benefited the fast worker and penalized the slow, careful one. Guessing was quite out of question since an entire series had to be correct in order to receive credit.

Two possibilities according to which the test could be scored were discussed. First, since there were three empty

spaces in each series and one hundred twenty-six in all, each space could have been given a score and the total number of spaces filled correctly would be the individual's score. However, because this system allowed guessing on one or even two numbers without seeing the relationship of the whole group, the simple method of counting only entire series that were completed correctly was used as criterion in scoring the papers. On the basis of the latter, the complete test would have a score of forty-two. The number of series answered correctly is the score for each individual.

The final phase of the work had to do with statistical analysis of the data. Separate means and standard deviations were calculated for each grade group.

The primary object of this study was to ascertain whether differences in inductive reasoning ability exist among children at different grade levels in the upper grades. The statistic used to determine this relationship was the critical ratio. Critical ratios were determined between the means of grades five and six, six and seven, and seven and eight.

## CHAPTER IV

### RESULTS: STATISTICAL ANALYSIS

The subject matter of this chapter will be statistical analysis and interpretation of the results of the Loyola Induction Study with 400 subjects on the fifth, sixth, seventh, and eighth grade levels.

After collecting and scoring the booklets, the scores were statistically analyzed to determine the effectiveness of the test in showing differences in inductive reasoning at adjacent grade levels.

To determine statistically the significant differences between the obtained scores, the mean, standard deviation, and the standard error of each group were secured. From the latter the standard errors of the differences of adjacent means were computed. To establish the level of confidence, critical ratios were calculated for each pair of adjacent means. These data are presented in Table I (page 16).

The formula used for computing the standard error of the differences between the means was that of McNemar (4).

$$\sigma_{D_M} = \sqrt{\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}}$$

TABLE I

COMPARISON OF MEANS OF INDUCTIVE REASONING TEST SCORES  
AT ADJACENT GRADE LEVELS IN THE UPPER GRADES

GRADE	MEAN	S. D.	D M	S.E. M.	S.E. D.	CR	CONFI- DENCE LEVEL
5	13.34	7.44		.744			
			3.36		1.15	3.54	.001
6	16.70	5.91		.591			
			2.28		.998	2.28	.05
7	18.98	8.04		.804			
			4.32		1.23	3.82	.001
8	23.30	7.17		.717			

Examining critically the results obtained through the statistical methods described above, it is quite apparent from Table I that definite progress in inductive reasoning is made at contiguous grade levels. What accounts for the individual differences in inductive growth? Training and maturation would definitely affect this ability. The mean scores indicate that capacity for inductive reasoning grows and develops gradually with age and maturation. The differences in the means are highly significant. However, a difference of more than three points appeared in comparing the fifth and sixth grade mean scores, and even more between the seventh and eighth grade scores. A difference of only 2.28 appeared between the sixth and seventh grade scores. In a population as large as this, one would expect this difference to closely approximate the difference of the other adjacent grades. What explanation can we offer for the occurrence of the lesser difference between the sixth and seventh grade population? This departure from the established pattern of the other grades in the experiment is not easily explained. Each of the four seventh grades tested has a more or less similar scatter of correct responses. Hence, no one particular school can be responsible for lowering the mean. Factors like motivation, attitude, conditioning were not likely to influence the performance because the children were not informed in advance of the type of task to be present-

ed to them. The teachers likewise were not aware of this. Could this age group fear number work, which in children's minds is so closely related to arithmetic study? Was this group of a mentally poorer caliber?

A mean difference of 2.28 was found between the sixth and seventh grade population in comparison to the difference of 3.36 yielded by the fifth and sixth grades and 4.32 obtained by the seventh and eighth grade groups.

Critical ratios were determined between the mean scores of the successive grades. Here again it can be noted from the study of this sample that the Loyola Induction Study shows a significant difference at adjacent grade levels. Although the .05 level of confidence between the sixth and seventh grades is significant, it is low when compared with .001 of the other grades. The wider the gap in scores between the grade levels, the more significant the critical ratio becomes, and thus chance becomes less a factor in explaining differences in the mean scores.

The t value for difference in performance between boys and girls was far from reaching significance even at the .10 value.

Careful examination of the exact grade placement in the public and parish schools and of the I.Q. furnished by the schools yields no explanation for the slight discrepancy in



the seventh grade scores.

Further analysis of the test data revealed that the highest score (41) was obtained by an eighth grade subject. Two fifth grade subjects scored 40. One sixth, two seventh, and ten eighth grade subjects made the last item in the test correctly. The only series uniformly correct at any one level was the first series which all of the sixth grade subjects completed correctly.

A graph to illustrate the gradual increase in the means of the successive grade levels appears on page 20.

Out of a total of 16,800 items in the complete test an aggregate score of 7237 was obtained by the entire group tested.

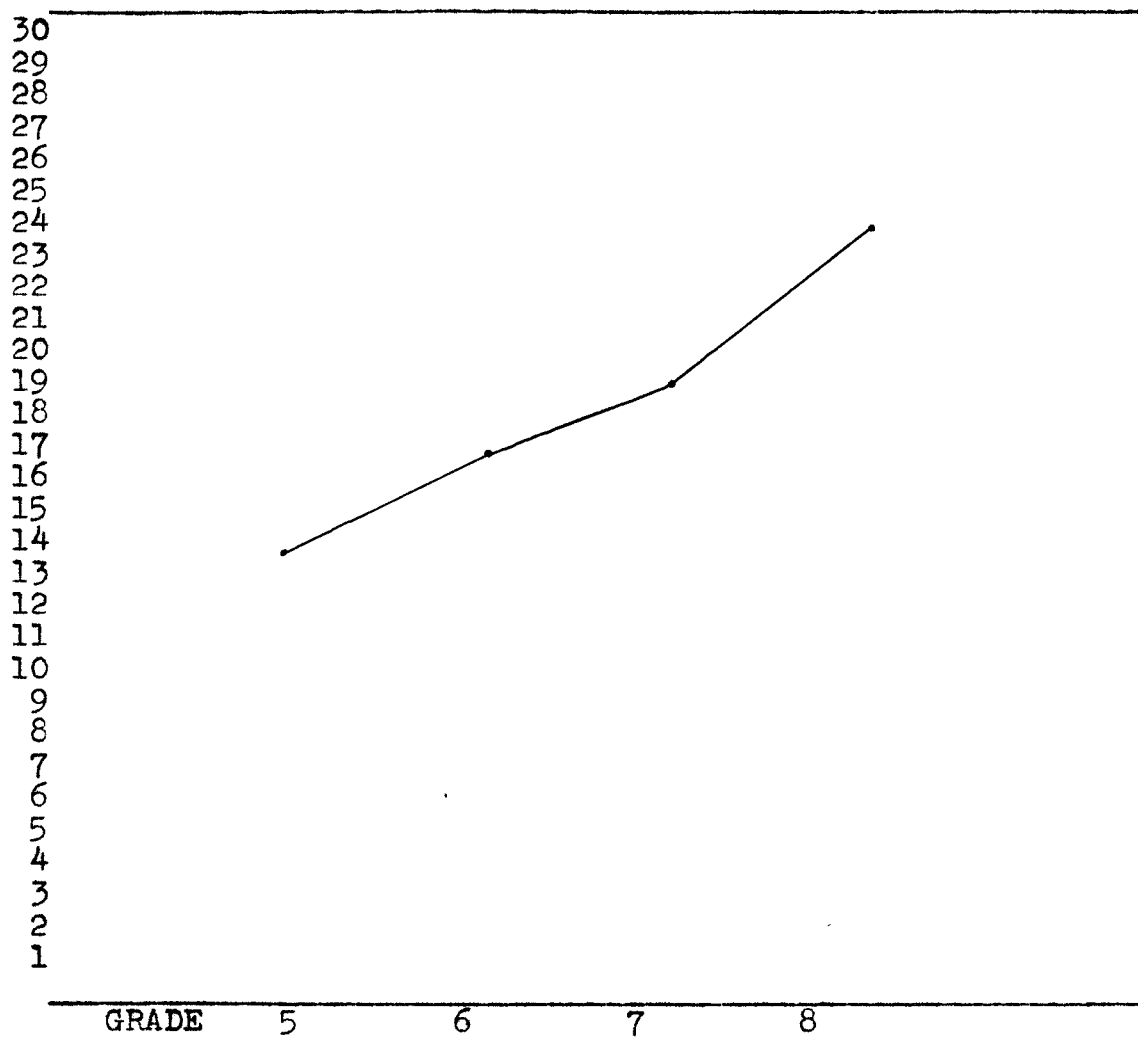


FIGURE I. MEAN SCORES OF 100 PUPILS AT EACH GRADE LEVEL FROM GRADE 5 THROUGH 8

## CHAPTER V

### SUMMARY AND CONCLUSIONS

We can now bring the foregoing results and theoretical discussion to bear upon the problem with which the present study was primarily concerned, that is, the degree of effectiveness of a number series test of inductive reasoning in discriminating differences among children at adjacent grade levels in the upper grades.

The investigation included the testing of a population of 400 children, 100 at each of the fifth, sixth, seventh, and eighth grade levels, scoring the tests, and tallying the scores. The total number of correct responses made up the individual's score. To obtain a representative picture of the entire group, the means, standard deviations, standard errors, and the standard errors of the differences of the means were calculated. Critical ratios were computed to assess the significance of the differences between the means.

In reviewing literature related to the subject, a considerable amount of material dealing with the theory of induction written late in the nineteenth and early in the twen-

tieth century concerned itself mainly with thought processes and the inductive methods of teaching. Number series were used for testing mathematical ability and were later included as parts of many intelligence tests. To the writer's knowledge the number series were not used as a single instrument to determine any similar reasoning ability in the grades in the growth of inductive reasoning.

The analysis of scores on the Loyola Induction Study revealed a significant difference between the scores of contiguous upper grades. They indicate an apparently regular progression in the ability to reason inductively among the children included in this investigation. The statistical analysis verifies the validity and reliability of the number series to test inductive reasoning ability.

In summarizing the data obtained in this study, the following specific conclusions were made:

1. The experiment contributes evidence that inductive reasoning is not a static thing, but a dynamic relationship within the personality.
2. Inductive reasoning develops with age and maturation.
3. Since children of ten showed well-developed capacity for inductive reasoning, it seems safe to assume that children begin to think inductively well before that age.

4. The differences in performance between boys and girls were negligible; that is, far from reaching any significance.
5. On the basis of this test the ability to think inductively can be measured with considerable reliability, indicating that we are measuring a variable in which chance plays only a small part in determining the score of the individual.

The scope of this thesis has been limited. No attempt has been made to learn whether the obtained results correlate with any criterion. Much can be done yet, experimentally, in the field of inductive reasoning.

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APPENDIX

TEST FORM AND DIRECTIONS



## Directions for Administering

"Boys and Girls,

"Everyone in the world today is talking about Sputniks, Explorers, and trips to the Moon. Every nation is trying to outdo the other in scientific research. I am helping to do some scientific research in our schools that may help someday to spot future scientists, mathematicians and engineers.

"Do you want to help me? Good ... to do that won't be very difficult.

"I'll give each of you a sheet of paper on which you will find rows of numbers. Each row follows a certain pattern or sequence. There are six numbers in a row and three empty blanks. You'll notice that each row of numbers follows a certain sequence or order. I want you to figure out what the pattern is and then to write the numbers that should follow in the three empty spaces.

"They begin with a very easy series like this one. Do you want to watch one or two samples at the board? For our first sample the numbers are: 1 2 3 4 5 6 \_ \_ \_ . Of course you know what numbers should follow in the next three blanks ... 7, 8, 9. That is right. Let us look at another sample row. Here

it is: 19 17 15 13 11 9 \_ \_ . What numbers would you write in the empty spaces? That is correct, 7, 5, 3.

"First of all, on the top sheet, that is, on the top of the folded sheet write the following information:

Name \_\_\_\_\_ Age \_\_\_\_\_ Grade \_\_\_\_\_  
School \_\_\_\_\_ Date of Birth \_\_\_\_\_

At the end of ten minutes tell the children to stop. Then say: "Draw a line under the last row of numbers you have worked. Now continue with the other rows."

Directions: Read each line of numbers and write in the blanks the numbers that should follow.

2	4	6	8	10	12	—	—	—
9	8	7	6	5	4	—	—	—
1	7	2	7	3	7	—	—	—
2	2	3	3	4	4	—	—	—
1	4	7	10	13	16	—	—	—
14	16	18	20	22	24	—	—	—
3	6	9	12	15	18	—	—	—
32	30	28	26	24	22	—	—	—
21	22	31	32	41	42	—	—	—
10	10	15	15	20	20	—	—	—
17	51	17	51	17	51	—	—	—
1	3	5	7	1	3	—	—	—
1	2	2	3	4	4	—	—	—
21	22	24	25	27	28	—	—	—
12	21	13	31	14	41	—	—	—
8	6	4	2	8	6	—	—	—
24	27	28	31	32	35	—	—	—
19	19	18	17	17	16	—	—	—
46	44	41	39	36	34	—	—	—
91	18	71	16	51	14	—	—	—

32	1	16	1	8	1	—	—	—
2	3	5	8	12	17	—	—	—
39	34	30	25	21	16	—	—	—
5	6	4	7	3	8	—	—	—
70	62	54	46	38	30	—	—	—
2	10	17	23	28	32	—	—	—
16	17	15	18	14	19	—	—	—
3	6	9	2	5	8	—	—	—
20	17	15	14	11	9	—	—	—
42	41	37	36	32	31	—	—	—
1	4	9	16	25	36	—	—	—
28	31	33	36	38	41	—	—	—
15	18	14	17	13	16	—	—	—
3	6	8	16	18	36	—	—	—
39	38	36	33	29	24	—	—	—
7	4	1	8	5	2	—	—	—
15	18	24	33	45	60	—	—	—
50	42	35	29	24	20	—	—	—
2	4	6	12	14	28	—	—	—
17	19	21	18	20	22	—	—	—
2	4	3	9	4	16	—	—	—
5	10	8	16	14	28	—	—	—

### APPROVAL SHEET

The thesis submitted by Sister Mary Colomana Buksa, C.S.S.F. has been read and approved by three members of the Department of Psychology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Arts.

May 7, 1960  
Date

Charles J. Doyle, Jr.  
Signature of Adviser