The Relation Between Intelligence and Transfer

by

Arthur M. Sullivan

A dissertation

submitted in Partial Fulfillment of the

requirements for the Degree of

Doctor of Philosophy

McGill University
Montreal, Quebec.

May, 1964.

Acknowledgements

The writer here wishes to express his appreciation to all who have contributed toward the completion of this research. I am particularly grateful to Mr. P.J. Hanley, Deputy Minister in the Newfoundland Department of Education, for his assistance and support. The cooperation of the principals and teachers of the schools in St. Johns and Montreal, in which the testing programme was conducted, is sincerely appreciated.

Table of Contents

Chapter 1

Introduction

The purpose of the present research project is to investigate the area of individual differences in transfer and to relate these to individual differences in intelligence. This chapter reviews briefly the general area of transfer. Specific evidence from previous investigations of the relation between transfer and intelligence is presented and relevant evidence from closely associated areas of research is introduced. Finally, an attempt is made to provide a theoretical framework within which the relation between individual differences in transfer and intelligence may be understood and specific hypotheses presented.

Various definitions of transfer have been proposed. Brogden (1951) offers the following definition: "Transfer is the change in the proficiency of a performance that is demonstrated, by appropriate control procedures, to be a function of a change in the conditions under which it was originally acquired or in the conditions under which a similar performance was previously acquired." Woodworth & Schlosberg (1958) distinguish between the terms "transfer" and "transfer effect," pointing out that: "The distinction between the two terms is not always observed but logically 'transfer' means the carrying over of an act, or way of acting, from one performance to another, whereas 'transfer effect' means the effect of this transfer upon the learning or execution of the second performance." Woodworth's distinction seems a useful one and an attempt

will be made to use the terms "transfer" and "transfer effect" as he suggests.

Some writers distinguish between three types of transfer effects. McGeoch and Irion (1952) state that: "Transfer effects may be

(a) positive, when training in one activity facilitates the performance or acquisition of a second activity;

(b) negative, when the training in one inhibits or retards the learning or performance of another; and

(c) zero or indeterminate, when training in one has no observed influence on the performance or acquisition of the second.

The great majority of the experiments on these problems have obtained either positive or negative transfer with positive transfer predominating."

The above distinctions represent an over-simplified conceptualization of the area and, in a later section, it will be demonstrated that in more complex interaction between training and performance various modifications must be introduced. For the present, however, in reviewing the literature, the distinctions suggested above will be maintained.

In the experimental investigation of transfer, the customary design involves the use of an experimental group, which is given a specified amount of training or practice on a particular activity. This training is followed by a test on an activity which is presumed to be different from, but influenced by, the preliminary training. A control group, matched with the experimental group on initial ability to perform the test activity, is given practice or training on some presumably unrelated activity, and

is given the final test under the same experimental conditions as the experimental group. The amount, and the sign, of the resulting transfer effects is calculated from the difference in the scores between the experimental and control groups.

Many experiments on transfer have used simple psychomotor tasks or the memorization of nonsense syllables as the training and test activities. The advantages of these types of material are that the amount of training, in terms of number of correct responses, or the number of trials to reach a criterion, can be specified and the scores on the test trials can be obtained, easily and reliably, in the same manner. Also, training and test activities can be varied so that the training will be more, or less, similar to the test.

Experiments on transfer using these types of material have been concerned, primarily, with the investigation of three principal aspects of the problem.

(1) The degree of similarity between training and test stimuli and between training and test responses. Experimenters have attempted to vary, systematically, the degree of similarity between stimuli and between responses. Although the problem of assigning precise degrees of similarity is a difficult one (Gagné and Bolles, 1963), it is possible, particularly with nonsense syllables, to provide new material which differs in a systematic degree from the original. General conclusions provided by Yum (1931), Bruce (1933) and Gibson (1941), suggest that transfer effects, positive and negative, increase with the stimulus similarity between training and test activities. The sign of the transfer, i.e. whether the

effects will be positive or negative, depends upon the similarity of the response relations, with similar but incompatible responses producing maximum negative transfer. The findings in this area have been summarized and given a theoretical interpretation by Osgood (1949, 1953).

(2) The amount of practice received during the training session. Transfer effects have been measured after the experimental groups have received amounts of training which vary from one trial to several hundred trials. One important conclusion is that increased practice usually increases the amount of positive transfer and may change initially negative transfer effects to positive (Bruce 1933), Siipola and Israel (1933), Duncan (1953) and Mandler (1954). The amount of time necessary to learn successive lists of nonsense syllables decreases, suggesting an increase in positive transfer effects with increased training (Ward, 1937).

(3) The amount of time between training and test. Training produces a "warm up" effect, or set to perform, which facilitates future learning but seems to be independent of transfer of training in the usual sense of the term, since little or no learning need occur on the first task, and the effect dissipates rapidly in time (Hamilton, 1950). Because of this it is necessary to specify the interval between training and test sessions.

The duration of transfer effects, apart from this warm up effect, appears to vary with the amount and type of training and the sign of the resulting transfer effects, but the area has not been thoroughly investigated. Bunch (1936), using the Peterson Rational Learning Problems, found that positive transfer effects persisted without any significant

diminution for 90 days. Vernon (1954) reports that transfer effects may be observed for more than six months after the original training. These two studies suggest that with complex material transfer effects are long lasting and may, perhaps, be permanent.

In the last paragraph, results from experiments in transfer involving complex problems solving material were introduced. Investigation involving this type of material has concentrated, primarily, on two important problems:

(1) Learning to learn. The results of Ward (1937) show that efficiency in learning nonsense syllables increases with the learning of successive lists, and other workers have reported that positive transfer effects increase with additional practice. This area has been most thoroughly explored by Harlow (1949), who demonstrated that monkeys will show extremely rapid problem solving after learning to solve a large number of problems of a similar type.

Of course, training in methods of problem solving can produce negative transfer effects when the principle by which the problem may be solved is suddenly changed. This aspect of transfer is closely related to set, and this area has been thoroughly investigated by Luchins (1942).

(2) Non Specific Transfer. Judd (1908) varied the type of training which two experimental groups received. One group received practice in throwing darts at an underwater target, while the second group received, in addition, instruction in the principles of refraction. The second group showed the greatest positive transfer effects when the depth of the water was changed. Hendrikson and Schroeder (1941) repeated Judd's

experiment, using an air rifle and an underwater target, and report results which generally confirm Judd's original findings. Woodrow (1927) demonstrated that training in general techniques of memorizing produced more positive transfer effects than did undirected practice in memorizing. Katona (1940), using very complex problems, concluded that learning a problem with understanding of the relations involved in it has higher transfer value than learning without understanding these relations.

General, or non specific, transfer has been intensively investigated in recent years and tentative conclusions may be proposed. In a simple transfer situation, that is, when the transfer tasks are highly similar to the tasks upon which the original training was given, simple memorizing produces as much transfer as does training in understanding. In more difficult transfer situations, that is, when the transfer problems are different from, and more complex then, the original problems, training in understanding general principles produces greater transfer gains than does simple memorizing (Hilgard, Irvine and Whipple, 1953; Hilgard, Edgren and Irvine, 1954; and Crannell, 1956). For older subjects, the independent discovery of the principles involved produces greater positive transfer effects than does having the principle stated (Halserud and Meyers, 1958), but, for younger subjects, "guided discovery" of the principle is necessary (Kittell, 1957). Verbalizing the principle may reduce positive transfer effects (Hendrix, 1947). Training on a small number of problems is more effective than training on one problem or many problems (Morrisett and Hovland, 1959). When the trans-

fer situation becomes extremely difficult, that is, when a new computational principle is involved, only about half of the subjects demonstrate positive transfer effects (Buswell, 1956).

Thus, many aspects of transfer have been thoroughly and intensively investigated, and a considerable amount of experimental evidence concerning all of the above areas may be found in the literature. In the preceding section, representative studies from each area were presented, but no attempt was made to present an exhaustive summary of all previous investigations because practically all studies on transfer have been concerned with the investigation of general principles of transfer and the conditions under which maximum transfer effects occur. Individual differences in transfer are rarely mentioned and, in the few studies which report that only some subjects demonstrated transfer effects, there was no attempt to relate these differences in transfer to any other individual difference variables.

There have, however, been suggestions that individual differences in transfer are of considerable practical and theoretical importance and may be associated with differences in intelligence.

James (1930) states that "It seems likely that there will be a positive correlation between amount of intelligence and the extent to which such connections (transfer between old and new situations) are made." He adds that "The relation between transfer and intelligence still awaits adequate investigation."

Townsend and Burke (1962) propose that "The ability to recognize the general principles embodied in the strange situation is an example of in-

telligence. Those of higher intellectual level have more of this ability, and can thus transfer more of the things they learn because they can generalize and discriminate more. They are aware of more relationships and of more nuances among relationships so that they transfer their abilities with more skill and greater ease."

Stephens (1963) states "Intelligence has long been assumed to be an important factor in transfer. It would be amazing if the intelligent student were not more successful in perceiving and formulating the general principle; and if, as we have suggested, this formulation of the general principle is an aid in transfer, the bright student should have an advantage."

These authors, then, propose a direct and definite relation between intelligence and transfer, but provide no experimental evidence to support such a proposition. A search of the literature reveals few studies which attempt to investigate this relation and the results of the studies which are found are not entirely consistent and do not permit unequivocal conclusions.

Thorndike (1924), while studying the transfer effects produced by different school subjects, reports that no subject was found which would produce significantly greater transfer effects than any other, but also reports that brighter students transferred more than duller ones from any combination of school subjects. Thorndike's pre and post tests were alternative forms of the I.E.R. Tests of Selective and Relational Thinking. The brighter subjects showed average increases of 20 points, whereas the gain for the dullest pupils averaged 1.5 points. Essentially the

same findings are reported in a later study by Broyler, Thorndike and Woodyard (1927), and a similar study by Wesman (1945).

Brooks (1924) investigated "The Transfer of Training in Relation to Intelligence", using 160 pupils from Grades VI, VII and VIII as subjects. Pre and post training tests consisted of tests of various arithmetic operations. The training period of 20 minutes per day for several days was devoted to mental multiplication. He reports that the amount of transfer effect was associated with the type of test material. The greatest transfer gains following training were found on tests of division and immediate memory span. There was also a tendency for transfer effects to be correlated positively with intelligence as measured by a standard numerical verbal intelligence test, but the correlations were small. The highest correlation, +.11, was found in Grade VI, and the lowest, +.06, was found in Grade VIII.

Carroll (1930) investigated the generalization of bright and dull children in spelling. He found that, after training in phonetic spelling, there was no significant difference between bright and dull in detecting single letter errors but that the bright children were definitely superior in phonetic translation.

Ryans (1936) found that brighter subjects showed greater negative transfer effects than did duller subjects. All subjects were given a series of trials in which numbers were substituted for letters. After five minutes they were given a further series of trials, but, on the second test, the substitution code was changed so that different numbers were substituted for the same letters. Brighter subjects demonstrated a

reduction in number of substitutions and an increase in number of errors, while duller subjects demonstrated an increase in the number of substitutions and a decrease in the number of errors.

Barlow (1937), using interpretation of Aesops' fables as pre and post training tasks, and instruction in the principles of simple analysis, abstraction and generalization as the training, found that the more intelligent children showed greater transfer gains but the reverse was true for the adult subjects, with the least intelligent showing greatest gains.

Kuenne (1946), working in a related area, demonstrated a relationship between mental age and the occurrence of transposition behaviour in children. She studied transposition behaviour on near and remote pairs of stimuli with children who ranged in mental age between 36 and 83 months. At all mental age levels, transposition to a high degree was obtained when test stimuli were near to those used in training. For the remote-test stimuli, mental age was a significant variable. As mental age increased, percentage of correct transposition responses increased from chance level at 46 months to a level of 100 per cent at a mental age of 76 months.

Bialer (1961), using subjects of normal and defective intelligence, and a transfer task involving conflicting verbal and sensory cues, found a significant positive relation between I.Q. level and transfer score. He interpreted these results as indicating that the higher I.Q. groups responded significantly more on the basis of secondary stimulus-generalization than did the lower I.Q. groups.

The above studies strongly suggest that there is a positive relation between measured intelligence and positive transfer effects, particularly in the case of young children. But the results are meagre and not entirely consistent, especially in the older age groups where an increase in negative transfer effects and an inverse relation between intelligence and positive transfer effects have been reported.

In general, the experimental investigations of transfer have been, to a certain extent, disappointing. Emphasis has been placed on the conditions under which maximum transfer effects occur and, although consistent results have been obtained in situations using simple material and easy transfer, it has not been possible to apply the general principles, which have evolved, to practical educational situations. In situations involving more complex material and more difficult transfer, some important conclusions have been suggested, but there are, as yet, no general principles which provide a comprehensive and consistent framework for the area.

It is generally recognized that the more difficult transfer situations are of the greatest practical and theoretical importance to the understanding of all manifestations of learning. Many writers have indicated their awareness of the importance of this type of transfer.

McGeoch and Irion (1952) assert that transfer is of fundamental importance. "Transfer serves to determine, in part, the ease of learning a particular habit and indeed, every new learning takes place in the context of all previously established habits....The action of transfer in the laboratory and in more practical learning situations is

inescapable. Few "new" materials or activities are wholly new to a person beyond the earliest period of his life with the result that past experience may influence present learning in either a positive or a negative manner. New learning problems are usually solved in terms of previously acquired specific acts. Furthermore, the changed associative organization, which each new instance of learning brings about, becomes, in turn, a determiner of future learning....Positive transfer, in fact, is a major facilitating device or "shortcut" in mental organization. It is probably the major condition of the empirical phenomena of understanding and insight. Negative transfer, on the other hand, is one of the major inhibitors of further learning and of retention."

Hebb (1949), commenting on a similar quotation from McGeoch (1942), agrees with the position taken and adds "in the case of the mature animal there must be a serious risk that what seems to be learning is really half transfer."

Bruner (1960) states that "this type (nonspecific transfer or more accurately, the transfer of general principles and attitudes) of transfer is at the heart of the education process."

It appears that the concept of transfer, which has guided much of the previous experimental investigation, has been exclusively narrow and rigid. Transfer has been considered to be a clearly distinguishable, and perhaps atypical, form of learning. It has been assumed that the principles which are associated with learning are different from those which are associated with transfer.

Transfer, as the term is generally used, implies that there is a difference between the conditions under which a skill, or a particular unit of information, was originally acquired, and the conditions under which this skill, or information, is demonstrated to have an effect. If training or practice on one activity can be demonstrated to have an effect upon the performance of a "different", but somehow related activity, or upon the performance of the same task under "different", but somehow related, conditions, then the term transfer is used.

On the other hand, the use of the term learning implies that there is "no difference" between training and test conditions. If previous practice or training can be demonstrated to produce an effect upon performance of "the same" or "highly similar" activity under the "same" or "highly similar" conditions, then the term learning is used.

The conventional distinction between the two terms is, therefore, seen to depend, primarily, upon the use of similar and different. It is obvious that no two activities are identical. There are differences between any two successive trials in a typical learning sequence. Also, no two activities are so different that they are completely unrelated in every respect. The amount of difference between any two trials or any two activities will vary considerably but the difference will be in degree rather than in kind. The scaling of degrees of difference and similarity is an extremely complex process and there is not, at this time, any generally accepted method of assigning degrees of similarity, or difference to the relation between any two activities.

It follows that, in practice, it is impossible to discriminate between situations in which learning would be the appropriate term to use and those which would be more accurately described as transfer. It must be recognized that the use of the terms has been, to a certain extent, arbitrary, and the present distinction between the terms is based largely on historical precedent.

A more adequate formulation has been proposed by Ferguson (1954, 1956). He makes reference to the considerations presented above, and states "It seems, therefore, that transfer is the general phenomenon and 'learning' is a particular formal case which may never occur either in laboratory experimentation or in real life situations. The notion of learning implies the identity of a sequence of learning situations." Learning cannot be used to imply that succeeding trials are identical, because that is never the case. The term may be used when the skill to be acquired is completely novel, but this type of acquisition occurs only in the very early life of the individual and probably consists of the acquisition of basic sensory motor, and perhaps conceptual operations.

After the acquisition of these basic operations, all new acquisitions occur in the context of prior learning and are influenced by the amount and nature of previous acquisitions. In some cases, aspects of past experience will be obviously relevant to the present situation, and new skills or information will be acquired readily and rapidly. In other cases, the relation between past experience and the present situation will not be obvious, and it will not be a simple matter to bring the relevant aspects from past experience into use. Acquisition will then be a slow

process and, if improper and irrelevant aspects of past experience intrude because of superficial similarities, the process of acquisition may be retarded.

Theoretically and practically then, transfer, the general phenomenon, is more fundamental and important than learning, the special case. Two important considerations follow from this: First, it is probable that in transfer situations of an appropriate type, wide individual differences in transferability, that is, in the ability to identify and use relevant aspects of past experience, may be demonstrated. This point will be developed in a later section. Second, it is probable that many studies which are conventionally considered to be examples of learning are, according to the more comprehensive concept of transfer, outlined above, actually examples of the operation of transfer. These studies now become relevant to the problem of transfer and, in particular, studies of individual differences in learning may provide information which will be of value in understanding and predicting individual differences in transfer.

Attempts have been made to investigate the relation between intelligence and learning. Woodrow (1938, 1939) found that there was little evidence for a general learning factor, and that there was little relation between amount of gain on any task and intelligence. Woodrow concluded that intelligence is not necessarily associated with ability to learn. The tasks which he used were very simple and this may have been an important factor in producing the results which he obtained. More recently, Stake (1958) also found no evidence for a general learn-

ing ability, but did find that gain scores on almost all his tasks did correlate positively with intelligence and scholastic achievement.

Other investigations, however, do report evidence for a general learning factor. Tilton (1953), using standardized achievement tests with Grade IV pupils, reported a general factor in school progress which correlated positively with initial scores on academic achievement tests. Allison's (1960) study included a wide variety of learning tasks (psychomotor, mechanical, rote learning and concept formation), and demonstrated three principal factors: a conceptual learning factor which was related to general verbal intelligence and numerical ability, a mechanical and motor learning factor which was related to spatial mechanical ability, and a rote learning factor which was related to rote memory ability.

MacKay and Vernon (1963) report a study which provided, by gain scores on various learning tasks, considerable evidence for a general learning factor and also evidence for group factors associated with the learning of different types of material, principally verbal, numerical, and non-verbal.

These studies, again, are not conclusive, and are at times contradictory, but they suggest that, when materials of appropriate difficulty are used, a general learning factor, related to intelligence, will emerge, as well as group factors associated with the learning of different types of material, and specific factors involved in each learning task.

One further area of investigation appears to be of relevance to the relation between transfer and intelligence. That is the study of

the effect of practice and coaching upon intelligence test scores. Practice in this context refers to the completion of alternative forms of the same test and so it involves experience with material which may be similar to, but not necessarily identical with, the material encountered in a later test situation. Coaching involves directed training on sample items which are highly similar to those found in the later test. Improvement on test scores, which results from practice or training on similar but not identical material, results from the operation of positive transfer.

Many studies of practice effect appear in the literature. Thorndike (1922) concludes that the amount of gain due to practice effect is approximately the same, regardless of the ability of the individual, at least within the range of initial I.Q. levels between 70 and 130. He reports that there is a slight but non-significant correlation between amount of gain and initial score.

Adkins (1937) suggests that there will be a positive relation between initial score and amount of gain due to practice. Her results provide some support for this suggestion and she considers increase in scores to be primarily associated with increase of speed of performance on the test.

Otis (1939) states that practice on one form of his Mental Ability Tests will produce an increase of about four points, presumably at all initial levels, on scores obtained through subsequent retests on another form.

Holloway (1953) examined the effect of training and practice on scores on the Primary Mental Abilities Tests and the Weschler Intelligence

Scale for children. He found that training produced greater gains than did practice, on tests involving similar material, but when the test material was not similar to that used in training, the gains associated with practice were as great as those resulting from training. In all conditions there was a negative correlation between amount of gain and initial score.

Spielberger (1959), and Colver and Spielberger (1961), using the Miller Analogies Test, found significant improvement due to practice. The magnitude of the improvement was inversely related to the initial score.

Anastasi (1961) summarizes a large number of studies and concludes that significant increases in mean test scores have been found to be produced by practice on parallel forms of the same test. This finding is reported for a wide variety of subject groups and for a wide variety of test-retest conditions, but no reference is made to the relation between increase in score and initial score.

In England, a number of studies have been carried out to investigate the effects of practice and coaching in the Moray House Examinations. James (1953) reports that coaching produces a general gain which is not correlated with initial scores and which does not have a significant effect on the distribution of scores.

Wiseman and Wrigley (1953) report a study which examines the effect of practice and coaching upon subsequent test scores. Practice on several alternative forms of the same (Moray House) test produced substantial gains which are directly related to initial ability. The greatest gain,

of 21.9 points, occurred at the highest level of initial ability. At the average level of initial ability the gain was 11.1 points, and at the lowest level 3.9 points. Practice effects attain their maximum level after four practice sessions and do not change significantly with four additional practice sessions. The effects of coaching are not as obvious as those resulting from practice and tend to be negatively correlated with initial scores. The gains associated with coaching are lowest (5.0 points) at the highest initial level and highest (8.8 points) at the lowest initial level.

Peel (1952) reports on a series of similar studies and concludes "when a verbal test follows a few weeks after a similar test ..... the data show that practice effects appeared to improve with initial level of intelligence scores to reach a maximum effect at somewhere about the 120-130 points of I.Q. Thereafter the effect seemed to diminish again. This characteristic feature of the differential practice effect is shown in all full sets of data, and tests of significance showed that the trend is generally significant."

Dempster (1954) used tests including both verbal and non-verbal material and found that there was a tendency, in the case of boys, for a gain in non-verbal test scores to be associated with training in verbal material, but the gains resulting from such practice were small.

The studies presented above include inconsistent and contradictory results, but certain trends emerge:

(1) When a test with a high ceiling is used with subjects representing a wide range of initial ability, there is a tendency for gains, re-

sulting from a relatively small amount of practice on alternative forms of the same test, to be correlated with initial ability, at least up to the I.Q. range of 120-130. This tendency may be distorted when tests with a low ceiling are used, or when tests with a high ceiling are used with subjects of high initial ability. Practice in such cases is of most benefit to those of average, or low, initial ability and gain scores are not related, or are negatively correlated, with level of initial ability.

(2) Coaching, using directed training on material highly similar to that found in the test, produces gains which are not positively correlated, and may even be negatively correlated, with initial score.

(3) Practice on material which is not similar to the material used in the test produces much smaller gains than does practice on material which is similar. The operation of transfer, in this case, is obviously difficult, and little information is available concerning the relation between gains produced in this manner and initial test scores.

In order to place the foregoing material in proper perspective and to provide a complete framework for the relation between transfer and intelligence, it is necessary to examine the concept of intelligence in some detail.

It is, perhaps, unfortunate that practical development and application of intelligence tests has proceeded at a more rapid pace than has theoretical formulation concerning the nature of intelligence. The earliest tests of intelligence were designed to provide a rapid and accurate means of discriminating between individuals who were judged to

be intellectually dull and those who were not. Items in such tests were selected, not because they were compatible with a particular theoretical formulation, but because, empirically, their use could discriminate between groups who had previously, on the basis of academic achievement and teachers' ratings, been judged as bright and dull. Intelligence tests today are constructed in much the same manner, with the validation of the total test depending upon a high correlation with achievement, or expert judgement, or with other "intelligence" tests.

Speculation and theorizing about the nature of intelligence has, in the past, almost invariably used the scores obtained from intelligence tests as a starting point. Spearman (1904) intercorrelated the scores obtained by children on different measures of intelligence. He found high correlations between all the measures used and proposed his two factor theory of intelligence to account for these results. Spearman considered that a general factor, identified as "g", contributed to test performance on all tests of intelligence but that specific factors also contributed to the performance in specific tests. The nature of "g" is defined (Spearman, 1927) as the ability to discover relevant relations and the ability to educe relevant correlates. The nature of the specific factors varies with the type of problem presented by a test and the type of test material used. Spearman later recognized that, when the scores obtained from tests using very similar material were correlated, intermediate factors emerged, which shared some of the properties of the general factor and some of the properties of the specific factors, but his primary emphasis, theoretically and practically, was always placed on the general factor.

Later investigators have considered these intermediate, or group, factors to be of primary importance. Thurstone (1938), working with the test scores of university students, identified seven major group factors, which are clearly distinguishable and not highly correlated with each other, and which he identified as primary mental abilities. Later investigations have found additional group factors within many of Thurstone's primary mental abilities and other group factors which are not included in Thurstone's original classification. Recent investigations (French, 1954, Guilford, 1956) have identified over forty group factors which, in spite of some overlap, are considered to be distinguishable, one from another, and speculate that a complete list would include as many as seventy separate factors.

There have been attempts to provide a framework within which to interpret the result of such studies. One such attempt, which has gained wide acceptance, particularly among British investigators (Hunt, 1961), is to propose a hierarchical structure of abilities, or factors (Vernon, 1950). At the top of the hierarchy is a general factor, similar to Spearman's "g" or general capacity; at the next level of the hierarchy are the major group factors of verbal educational and practical mechanical skills, together with another factor identified as speed in simple operations. These main group factors subdivide into minor group factors at the next hierarchical level. The minor group factors include e.g. verbal, numerical, reasoning and perceptual abilities, which had been previously identified as primary mental abilities by Thurstone, as well as minor group perceptual and mechanical factors. Minute, specific factors emerge

with the factoring of tests which are used to measure the minor group factors, and these highly specific factors make up the fourth level of the hierarchical structure. Typically, investigations which use young children as subjects produce results which demonstrate a general factor which is of primary importance and which accounts, to a considerable extent, for the variance on all tests, while investigations with older subjects provide evidence for the increasing importance of major and minor group factors (Burt, 1949). The complex hierarchy, with a predominance of minor group and highly specific factors, is demonstrated by testing on adult subjects.

In addition to attempts which use scores obtained from intelligence tests as starting point for theorizing, recent theoretical speculations concerning the nature and development of intelligence (Hunt, 1961) have been given considerable impetus by the works of Piaget (1923, 1936, 1937, 1947), of Hebb (1949), and of Ferguson (1954, 1956).

Hebb points out that there are two different meanings which are associated with the term intelligence. One meaning, which he identifies as intelligence "A", refers to an innate quality of brain functioning, which is quite apart from the knowledge and skills which are acquired through experience, but which makes possible the acquisition of such knowledge and skills. The other meaning of intelligence, identified as intelligence "B", refers to the average level of comprehension, problem solving and intellectual functioning, in general, in the half grown or fully grown subject. It is emphasized that "A" and "B" are not different types of intelligence but simply different meanings which have been associated with the term. The development of intelligence "B" depends on the amount of

intelligence "A" and also upon the opportunity for the acquisition of new habits and skills provided by the environment. Measured intelligence, which is essentially a sampling of the abilities which have been developed, will be influenced by the amount and type of environmental stimulation. Intelligence "B", then, clearly is affected by the interaction with the environment, but it is also possible that the central processes which are associated with intelligence "A" may also be affected by environmental stimulation.

The experiments involving early environmental deprivation (Thompson & Heron, 1954) suggest that, in the case of dogs, restrictions of stimulation in early life produces a reduced problem-solving capacity in later life, which persists for some years and may be permanent. The observations of Goldfarb (1945), Dennis (1941, 1957), and Spitz (1945), suggest that similar deficiencies may occur in humans as a result of early deprivation.

Piaget has been concerned with the process of intellectual development in young children in particular, and asserts that during the course of development several distinct stages of intellectual functioning may be noted. The first stage, which occurs during the first 18 months, is associated primarily with the acquisition of sensory motor experience patterns. Following this, during the preconceptual stage and the stage of concrete operations, perceptual experiences are of primary importance, and complex operations, such as judgement and inference, are based primarily on perceptual evidence. Perceptually determined thinking is, during the later years of childhood, gradually replaced by logical thinking, which

becomes increasingly independent of perception, and at about 10-12 years of age the child enters the stage of formal operations. Thinking, at this time, is characterized by such properties as conservation and reversibility, which are normally associated with adult intellectual functioning. The interaction between the child and the environment is directed by the invariant function of assimilation and accommodation. Thus, during each stage, experiences are grouped into schemata. Subsequent experiences, which are perceived as having common properties with existing schemata, are assimilated into these schemata. Experiences which have few properties in common with existing schemata may produce a change, or accommodation, which leads to the formation of new schemata, and these new schemata will, in turn, make possible the assimilation and interpretation of further new experiences.

For Piaget, as well as for Hebb, the stimulation provided by the environment is of primary importance. Sensory and perceptual experiences determine the progress through the first stage of intellectual development and, at any stage of development, environmental stimulation may provide an accommodative modification in existing schemata. This accommodation will make possible a period of rapid development when experiences, which are related to the newly organized schemata, are rapidly assimilated. A similar concept is proposed by Cattell (1963).

Ferguson (1954) discusses the concept of intelligence and provides a theoretical framework for the relation between intelligence and transfer. He points out that much of what has been conventionally included in the term intelligence may actually be considered as "abilities" at various stages of formation. Three meanings of the term ability are distinguished (Ferguson, 1956). Ability refers "to measures of performance in any situation, these measures being subject to error in relation to an underlying latent variable, which is presumed to be a continuous monotonic increasing function of the observed measures of performance". Ability may also refer, in factor analysis, to a derivative of the first meaning, namely "the weighted additive sum of measures of performance on separate tasks, the weights being obtained by a process of mathematical analysis," which also implies a latent variable. The third meaning refers "to some attribute of the state of the organism which may be vaguely identified with neurophysiological structure and process is modified by environmental and genetic factors". Implicit in the use of the term ability is the consideration that, although level of performance in any area increases with age and experience, in the case of children performance is relatively stable for short periods of time and that, in adults, a crude limit is reached, at which level further practice produces no further improvement and lengthy periods of time without practice produce no impairment in performance.

With reference to abilities, such as reasoning ability, number ability, perceptual ability, etc., two important characteristics have been suggested: The first is that early in the life of the individual

these abilities are highly correlated, and the second is that with increasing age and experience the abilities become progressively differentiated and correlations between them are reduced. Evidence for these characteristics comes from the previously cited reports of Vernon (1950), Burt (1949), and of Garrett (1946) and Preston (1940). The study by MacKay and Vernon (1963) of the progressive differentiation of learning abilities is also relevant.

Thus, two aspects of the general factor problem must be considered; "We must account not only for the fact that abilities are in some degree positively correlated with one another but also for the fact that they are in some degree differentiated from one another" (Ferguson, 1954).

If it is accepted that all learning, with the exception of some that occurs very early in life, occurs in the context of prior experience, then it follows that an individual will learn more readily those activities which are facilitated by prior acquisitions and the positive correlation between abilities can be accounted for by the operation of positive transfer from these prior acquisitions. Non-specific positive transfer effects may, then, explain the evidence which gives rise to the notion of a general factor in intelligence.

The formation of abilities by positive transfer alone cannot explain the differentiation of abilities, so Ferguson proposes a two factor theory of learning: "This theory states that much learning, excluding some very early learning, involves not only transfer components which are common to prior learning and the learning of a new task, but also components which are specific to the new task. In terms of the factorial model,

this means that variation in performance at various stages of a task can be accounted for in part by the variations in prior acquisitions and in part by specific abilities that emerge and are formed during the process of learning the task itself. I should anticipate that, as the learning of certain classes of tasks combines through a series of stages, the variance attributable to general transfer components may decrease, whereas the variance attributable to abilities specific to the task itself, or common only to the task, will increase" (Ferguson, 1954). On the basis of the preceding theoretical conceptions, it is possible to provide a tentative formulation of the development of intelligence and of the relation between intelligence and transfer.

The abilities, which are conventionally included under the term intelligence, are dependent, for their initial development, on early perceptual and conceptual learning. The formation of a distinguishable ability requires a reorganization in existing conceptual structures. This reorganization, a process similar to accommodation, occurs when previously acquired general principles are recognized as being relevant to an immediately presented problem. The transfer of general principles makes possible the solution of a wide variety of problems in the present situation, and ability formation during the early stages may be characterized by a period of rapid development. Since most intellectual abilities share common general principles, the assessment of abilities, during the early stages of development, will reveal common characteristics, or a general factor.

There are wide individual differences in the ease with which general principles from one type of experience are recognized as being relevant

to another type of experience. Some individuals have the capacity to relate, and to transfer, general principles from a wide range of experience. These individuals will demonstrate early initial formation, and rapid development, of intellectual abilities. Other individuals, who have a lower capacity to relate and transfer, will only be able to transfer general principles when present problems are highly similar to relevant past experience, or when aided by specific directions which make the nature of the relation, between past and present, evident. These individuals will demonstrate later formation and more gradual development of intellectual abilities.

Training, on the general principles required by a later ability-test, with subjects who are at an early stage in the development of the ability, should produce individual differences in transfer effects. Brighter individuals should demonstrate larger transfer gains than duller subjects: also,brighter subjects would be expected to benefit from training on material which was very different from the material used in the test,while duller subjects would be expected to benefit only from training on material which was highly similar to the test.

During later stages in the formation of an ability, improvement in performance is closely associated with the acquisition and application of particular principles and specific units of information necessary to solve particular problems. Training in general principles during these later stages should be of most benefit to those who have not already transferred the general principles from past experience, that is, to the duller individuals. With older subjects, then, positive transfer effects, as a

result of training on general principles, using material similar to that of a later test, would be expected to be inversely related to intelligence, with less intelligent subjects showing the largest transfer gains. It is probable that a different type of training, which stressed content rather than general principles, would produce transfer gains, during the late stages of ability development, which would be correlated with intelligence. During the later stages, however, the situation is complicated because, as abilities reach their crude limit, improvement is more gradual, and the gains resulting from training would not be as large as the gains during the earlier stages of development.

The present research is concerned only with training in general principles. The following hypotheses will be investigated.

First, with subjects at an early stage in the development of an intellectual ability, training in the general principles required by the ability, followed by a test designed to measure level of performance of the ability, will produce positive transfer effects which are closely associated with intelligence, as measured by tests of general intelligence.

Second, increasing the difference between the material used in the training, and that of the test, will increase the difficulty of transfer. Under difficult conditions of transfer, only the brighter subjects will show positive transfer effects.

Third, with older subjects who are at a higher initial level in the development of the ability, training in general principles, using material highly similar to the later test, will produce positive transfer effects which are inversely related to level of intelligence, in that duller subjects will show the greatest transfer gains.

Chapter 2

Methods and Procedures

In order to investigate the relation between intelligence and transfer, and in particular to test the hypotheses presented in the preceding chapter, it is necessary to provide a procedure suitable for the experimental investigation of transfer, and to vary both the degree of difficulty of the transfer tasks, and the level of intelligence of the subjects.

Experimental Design

The design used throughout the study was a modification of the conventional procedure described earlier (see page 2). Briefly, matched Experimental and Control groups were formed. The Ss in the Experimental group were given a period of practice on an activity which presented the general principles necessary for the solution of items on an ability test. Subjects in the Control group were not given the practice but were occupied, during the training period, with an unrelated activity. At the end of the training period both groups were given a test designed to measure level of performance on the ability. Transfer effects were calculated from a comparison of the differences between the groups in scores on the ability test.

The actual score difference between the groups gives a measure of the amount and nature of transfer effects associated with practice, but this method of calculation has two disadvantages. First, the difference in score, between the groups, is influenced by initial level of performance. The higher the initial score the lower will be the amount of possible

improvement so that score differences will tend to be reduced at the higher levels of initial ability. Second, it is not possible to compare the amount of transfer obtained under different experimental conditions or when different materials are used.

These difficulties have been discussed at length by Gagné, Foster and Cowley (1948) who conclude that the expression of transfer effects in terms of percentage of possible improvement provides a measure of transfer which is comparable from one transfer situation to another, and which also compensates, to some extent, for differences in initial level. McGeoch and Irion (1952) accept this method of calculation and state "while there are certain limitations to this procedure there is no doubt that this method is the best one currently available for the study of transfer."

For the present study, transfer effects were calculated by comparing differences in scores between Experimental and Control groups and also percentage of possible improvement by using the formula suggested by Andreas (1960).

$$\text{Transfer percent} = \frac{E - C}{T - C} \times 100.$$

where E = score obtained by the Experimental group.

C = score obtained by the Control group.

T = maximum score possible on the test.

Transfer Tasks

Two abilities within the general area of reasoning were selected for investigation. These were the ability to complete a series of numbers

or letters, arranged in an orderly sequence,and the ability to provide the final term in words or figures, arranged in typical analogy item manner of presentation. These abilities were selected because previous investigation (Thurstone, 1938, Lorge and Thorndike, 1957, Furneau, 1956) indicated that convenient and reliable measures could be provided for each ability and a pilot study demonstrated that the level of performance on each ability could be raised significantly by practice.

Two series tests were prepared. The Number Series test consisted of 40 items from the Lorge-Thorndike Intelligence Tests (Houghton Mifflin, 1957). 8 items were taken from Level 3 (Grades 4-6), 27 items from Level 4 (Grades 7 to 9), and 5 items from Level 5 (Grades 10-12). The Letter Series Test consisted of 40 items from the Nufferno Speed and Level Tests (Furneau, 1956). 29 items were taken from GI.S/14E.36 (forms A2 and B1), and 11 items from GI./3A-35. The items in both tests were arranged in approximate order of difficulty. A preliminary study, using Grade VIII pupils as subjects, demonstrated that average scores on both tests were low (Mean score on the Number Series Test was 22.8, mean score on the Letter Series Test was 20.4) and suggested that a considerable amount of improvement was possible, especially in the case of pupils in Grades lower than VIII.

In preparing the practice activity two requirements were given primary consideration. First, the practice must provide items illustrating the general principles involved in the series tests, and second, the items in the practice must be sufficiently simple that all subjects would be able to complete all, or almost all, items successfully. Accordingly,

the items of the series tests were examined and simple items illustrating each of the general principles involved were constructed. A total of 24 items, illustrating 6 general principles, were used in the practice activity. Preliminary use of the Practice with Grade VII and VIII pupils showed that over 80 percent of the subjects completed all items correctly and all subjects completed at least 18 out of the 24 items correctly.

Two Analogies tests were prepared. The Non-Verbal Analogies test contained 30 items, 5 of which were taken from Level 4 of the Lorge Thorndike Intelligence tests and 25 from Level 5. The Verbal Analogies test contained 30 items taken from the Lorge Thorndike Levels 4 and 5, Otis Mental Ability tests (Otis, 1939), Gamma Form (Grades IX-XII). The Verbal Analogies test was later expanded to 40 items by including 10 items which were constructed especially for this purpose.

Previous research (Spearman, 1927, Guilford, 1956) showed that the basic principles involved in reasoning by analogy can be demonstrated by using verbal or non-verbal (figural) material. Two parallel Analogies practices, a Verbal and a Non-Verbal, were constructed to meet the same requirements as those presented earlier for the series practice. Each practice contained 24 simple items which illustrated six general principles involved in each Analogies test. Preliminary testing with the Analogies tests and practice activities produced results similar to those reported above for the series tests and practice.

Copies of the Number Series test, the Letter Series test, the Verbal Analogies test, the Non-Verbal Analogies test, the Number Series

practice, the Verbal Analogies practice and the Non-Verbal Analogies practice, together with the instructions for administration of each test and practice are included in Appendix "A".

If the difficulty of transfer is assumed to vary with the difference between the practice activity and the test, each possible combination of practice and test might be presumed to provide a transfer task of varying difficulty. The greater the similarity between practice and test, with initial ability held constant, the easier the transfer, and the greater the difference between practice and test the more difficult the transfer would be expected to be.

Although it is impossible to assign precise degrees of similarity or difference, it was judged that, if the general principles involved in the practice and test were similar, the use of obviously similar material in practice and test, e.g. Number Series practice followed by Number Series test, provided greater similarity between practice and test, and hence an easier transfer situation, than the use of obviously different material, e.g. Number Series practice followed by Letter Series test.

Evidence reported earlier (Dempster, 1954) suggested that Non-Verbal Analogies practice followed by Verbal Analogies test, or vice versa, would provide the most difficult transfer condition.

The following transfer conditions were investigated:-

	Type of Practice	Type of Test
1.	Number Series Practice	Number Series Test
2.	Number Series Practice	Letter Series Test
3.	Verbal Analogies Practice	Verbal Analogies Test

Type of Practice	Type of Test
4. Non-Verbal Analogies Practice	Non-Verbal Analogies Test
5. Non-Verbal Analogies Practice	Verbal Analogies Test
6. Verbal Analogies Practice	Non-Verbal Analogies Test

Subjects

A total of 2500 pupils in Grades IV-X, ranging in I.Q. from 70 to 140, from schools in St. Johns, Newfoundland, and Montreal, were used as subjects. Most of the subjects were tested in St. Johns in May, June, September and December of 1963. Smaller groups of subjects were tested in Montreal in April and October of 1963.

Although subjects from rural Newfoundland have been found to obtain low scores on standard intelligence tests, it has been demonstrated (Sullivan, 1957; Burnett, Beach and Sullivan, 1963) that subjects from urban centres in Newfoundland, particularly St. Johns, obtain scores which are comparable in every respect with those obtained by subjects from other urban centres in North America.

Intelligence Tests

Two intelligence tests were used, the Otis Quick Scoring Mental Ability tests (Otis, 1939), and the Progressive Matrices test (Raven, 1956).

The Progressive Matrices test was designed to provide a measure of Spearman's "g", that is the ability to educe relevant relations and to educe relevant correlates on general reasoning capacity. Investigators (Westley, 1953) have claimed that the test is "an almost pure 'g'

test with a small loading on some perceptual factor." More recently, MacArthur (1963) conducted a factor analytic study, involving a large number of intelligence tests, and concluded that the Progressive Matrices Test demonstrated the highest loadings on the general reasoning factor, and that scores on the test were not influenced, to any appreciable extent, by verbal educational experience.

The Otis Mental Ability tests have been widely used, but have not been thoroughly investigated, and little information is available concerning the factorial composition of the test. However, the correlation between the Otis and the Progressive Matrices Test is relatively high. (Mean correlation between the two tests for 1200 subjects used in the present study was +.54). The correlation between the Otis and the Figure Analogies subtest of the Lorge Thorndike Intelligence tests, which MacArthur also found to have high loading on "g", was also high (Mean correlation for 100 subjects was +.64). It seems reasonable to conclude that the Otis test does measure general reasoning capacity, or "g", to a significant extent. On the other hand, as Lefever (1959) points out, over two-thirds of the items involve verbal material, so it seems equably reasonable to conclude that the test does measure verbal abilities as well as general reasoning capacity. Previous research (Sullivan and Schuurman, 1961) demonstrated that scores on the Otis test are significantly influenced by verbal educational experience.

The assumption will be made, then, that both the Otis and the Progressive Matrices tests measure general reasoning capacity but that the Progressive Matrices is a "purer" measure of this capacity and that the Otis test measures, in addition, specific verbal abilities.

Procedure

Matching subjects on level of initial ability presented a problem. Ideally, all subjects should have been given a pretest in the abilities to be investigated and Experimental and Control groups matched on pretest scores. It was found, however, that the use of a pretest produced significant gains in the scores of Control groups, which reduced and distorted the transfer effects obtained from comparing the differences in scores between the groups on the final test. However, scores on both the Series and the Analogies tests had been found to correlate highly with results obtained from the Otis Quick Scoring Mental Ability tests, Beta and Gamma Forms (Otis, 1939). It was decided to match subjects on scores obtained from the Otis tests and to assume that they had been matched for initial level on the abilities in question. Since large groups were used this procedure seems justifiable.

Subjects were tested in classes. All subjects were given the Otis test and, in addition, about half of the subjects were given the Progressive Matrices test (Raven, Revised Edition, 1956). Each class was divided into an Experimental and a Control group on the basis of the scores obtained from the Otis test, or from both the Otis and the Matrices tests when the two had been administered.

The Control group was sent to another classroom and continued with regular classwork under the supervision of the class teacher. The Experimental group was given the practice activity. In an attempt to reduce effects which might be attributed to differential learning during the practice activity, particularly in the case of subjects below Grade VII,

a coaching session was included. The subjects were given the correct answer to each item in the practice and, if a subject had completed an item incorrectly, the principle involved in the item was explained and further illustrations provided until he could complete a similar item correctly. This procedure is similar to the "guided discovery" method used in previous investigations. The time required for the practice session was usually 15 to 20 minutes. At the end of this time, the Control group returned to the classroom and regular class work continued for 20 minutes. This interval was included to reduce improvement associated with "warm up" effects. A longer period would have been desirable but, because breaks (e.g. intervals between classes, and recess periods) would have provided an opportunity for communication between Experimental and Control groups, it was not possible to extend the time between practice and test. After the 20 minute interval, the Series or Analogies test was administered to the entire class so that Experimental and Control groups were tested at the same time and under the same conditions.

In the testing during September it was not always possible to divide each class into Experimental and Control groups. Each class was given the preliminary intelligence tests and later the whole class was given practice, followed by the Series or Analogies test, or the test without practice. Experimental and Control groups were later formed within each school by matching subjects on the results of the preliminary intelligence tests. By using a matched pairs method and eliminating many subjects, it was found possible to provide Experimental and Control groups perfectly matched on both the Otis and the Matrices tests. The Series or Analogies test was administered at different times to each group, but,

since standard instructions were used for each administration and the time of testing did not vary by more than 30 minutes, the results obtained at this time were considered to be comparable to the results obtained by using the more rigid procedure described above.

Minor variations were introduced into the experimental procedure from time to time, in order to investigate specific hypotheses. These modifications will be discussed, as they were introduced, in the chapter on results.

Chapter 3

Results

The experimental procedure described in the previous chapter was first used with Number Series practice followed by Letter Series test as the transfer condition. A total of 128 Grade VII pupils (average age 13.5 years), 96 Grade VI pupils (average age 11.4 years) and 158 Grade V pupils (average age 10.7 years) were used as subjects. The Control and Experimental groups were each divided into four subgroups (I, above 120; II, 110-119; III, 100-109 and IV, below 100) on the basis of I.Q.'s obtained from the Otis test.

The results are given in Tables I, II, and III, and in Figure 1. Significant transfer effects, that is, significant differences between the mean scores of Experimental and Control groups on the Letter Series test, were found in each Grade and in each subgroup. For the Grade VII subjects, the largest transfer effect, calculated from actual score differences, was found in subgroup III (I.Q., 100-109). Although the absolute score differences decreased with increasing I.Q. for the higher subgroups, the transfer percentage was highly similar for all subgroups above 100. For the Grade V and Grade VI subjects the largest transfer effect, in terms of actual score differences and also transfer percentage, was found in subgroup II (I.Q. 110-119). For all three Grades the smallest transfer effect was found in the below 100 I.Q. range.

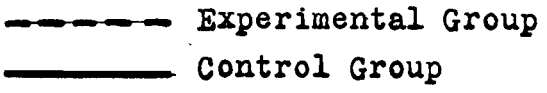
Clearly the experimental procedure produced significant positive transfer effects, and a tendency was observed, particularly in the

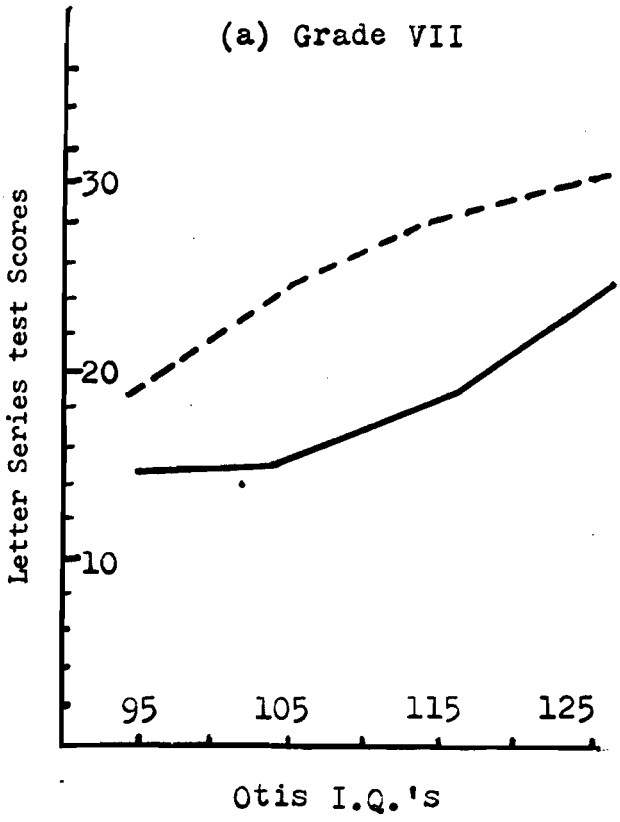
case of Grades V and VI subjects, for amount of transfer to be positively associated with level of intelligence. But, even with Grade V subjects, the largest transfer effects were not found in the highest I.Q. subgroup. Since the prediction was that, under this transfer condition, the largest transfer effects would be found in the highest I.Q. range, this finding requires some explanation.

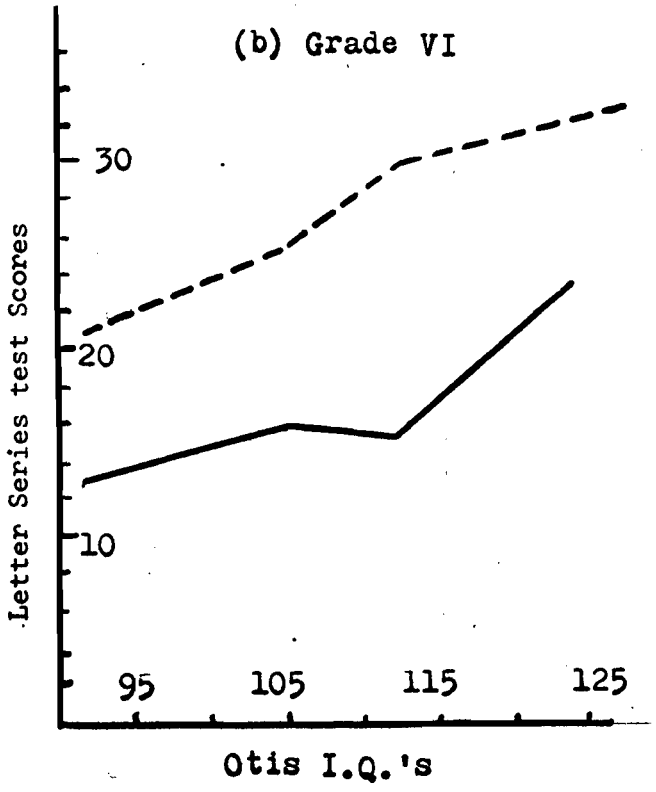
An examination of the within group differences for the three Grades reveals two important characteristics. First, for Grades VI and VII subjects, the more intelligent subjects in the Control group obtained high scores on the Letter Series test. The test discriminated well between the highest subgroups of the Control group. This suggests that the more intelligent subjects in these two grades have already acquired the necessary general principles, presumably by a process of non-specific positive transfer from previous academic experience. Training on general principles is, therefore, not as beneficial for them as it is for the less intelligent subjects who have not acquired the general principles. These subjects are, however, able to apply these principles, acquired during training, to the solution of problems on the Series test. Second, for all three grades scores on the Series test did not discriminate between the highest subgroups of the Experimental groups. This suggests that the more difficult items on the test cannot be solved by the application of general principles alone. These items require knowledge of particular relations not given in the practice session; consequently, practice is irrelevant for the solution of these difficult items. The effect of

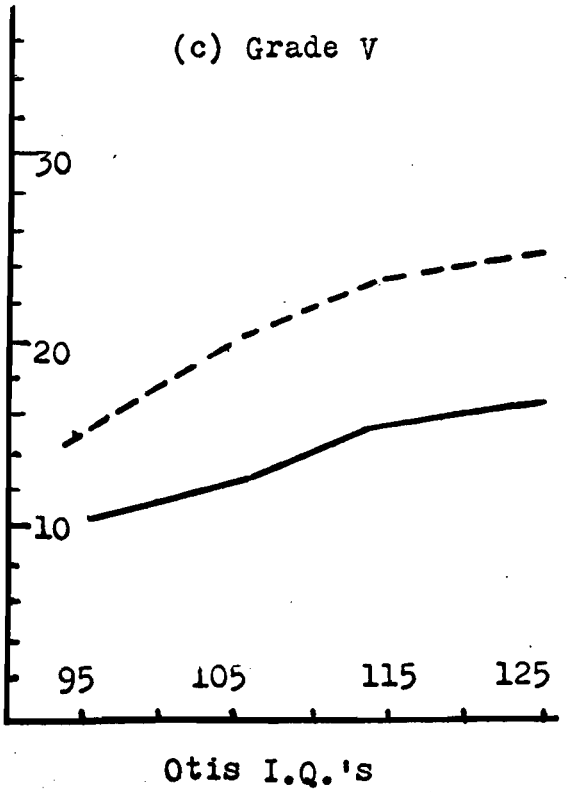
Fig. 1

Comparison of Scores
on the
Letter Series test
with
Otis I.Q.'s
For Grade VII, VI, and V
Experimental and Control
Groups









practice is, therefore, to create an artificial ceiling effect within the test. This reduces positive transfer effects at the highest level of intelligence.

In an attempt to compensate for both of these factors the Letter Series test was revised. An item analysis of the test, using the results of the Grade VI and VII subjects, showed the percentage of subjects in the Experimental and Control groups, and in both groups combined, which completed each item successfully. In this manner, it was possible to determine the level of difficulty of each item and to select the items which discriminated best between Experimental and Control groups. It was found that the most difficult items were those which did, in fact, require knowledge of particular relations not included in the practice. Also, items which could be solved by an application of one of the general principles included in the practice, discriminated best between the two groups. In preparing the revised test, the three items which had been found to be least difficult, and the seven most difficult, for the total group, were eliminated and ten new items were substituted. The new items were constructed so that they would be similar in type to those which had been found to discriminate between the groups. The Letter Series test (Revised) was administered to a group of 44 Grade VI pupils and it was found that the scores on the test correlated highly with I.Q.'s obtained from the Otis test ($r = .684$).

The Revised Letter Series test was next used in an experimental transfer condition with 74 Grade V pupils as subjects. The results are given in Table IV and in Fig. 2a. Significant transfer effects were

found for the total group and for each subgroup, except the lowest (I.Q. below 100). The largest transfer effect, measured by actual score difference and by transfer percentage, was found in the highest subgroup (I.Q. above 115). Also, Table IVb shows that the test did not discriminate between any of the subgroups of the Control group, but did discriminate between subgroups I and II, and II and III of the Experimental group. The correlation between Letter Series test scores and Otis I.Q.'s was low ($r = .203$) for the Control group, and high ($r = .709$) for the Experimental group.

In this particular transfer situation, then, transfer effects were produced which were directly and positively related to intelligence as measured by the Otis test. To confirm this finding with a transfer situation involving different material, and with an additional measure of intelligence, the same experimental procedure, using the Verbal Analogies practice followed by the Verbal Analogies test, was administered to 72 Grade VI pupils.

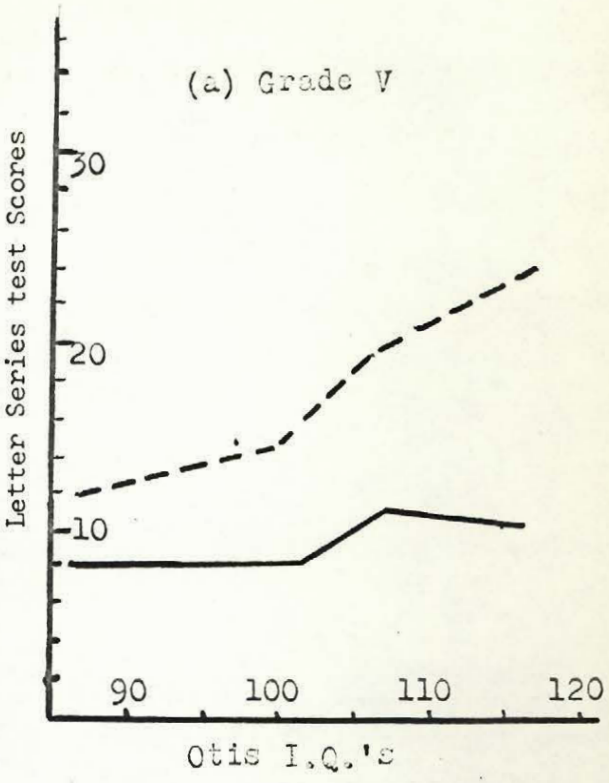
The subjects of the Experimental and Control groups were divided into three subgroups, (I, above 110; II, 100-109; and III, below 100), on the basis of I.Q.'s obtained from the Otis test.

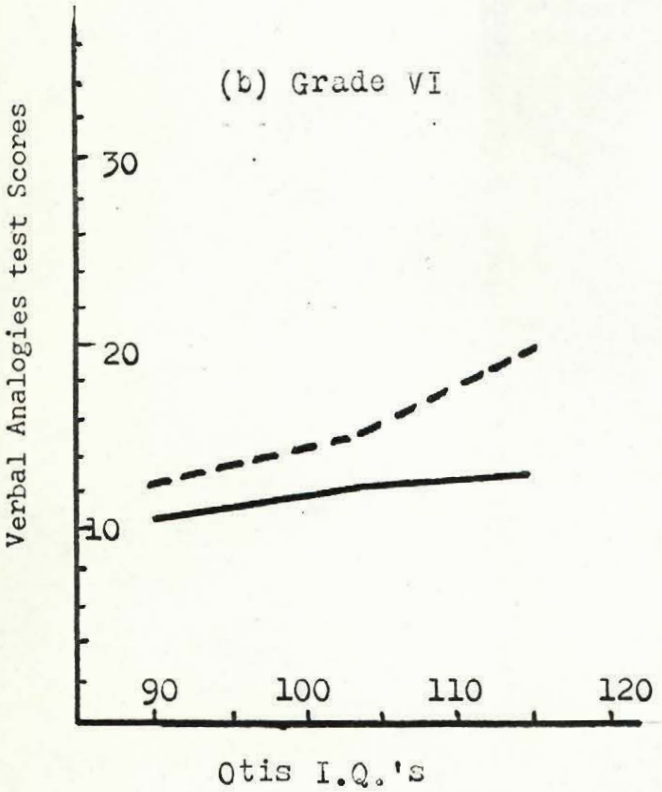
The results are given in Table V and in Fig. 2b. Significant transfer effects were found for the total group and for each subgroup. The largest transfer effect, measured by actual score differences or by transfer percentage, occurred in the subgroup containing the brightest subjects (I.Q. above 110), and the smallest transfer effect occurred in the subgroup containing the dullest subjects (I.Q. below 100). Although scores

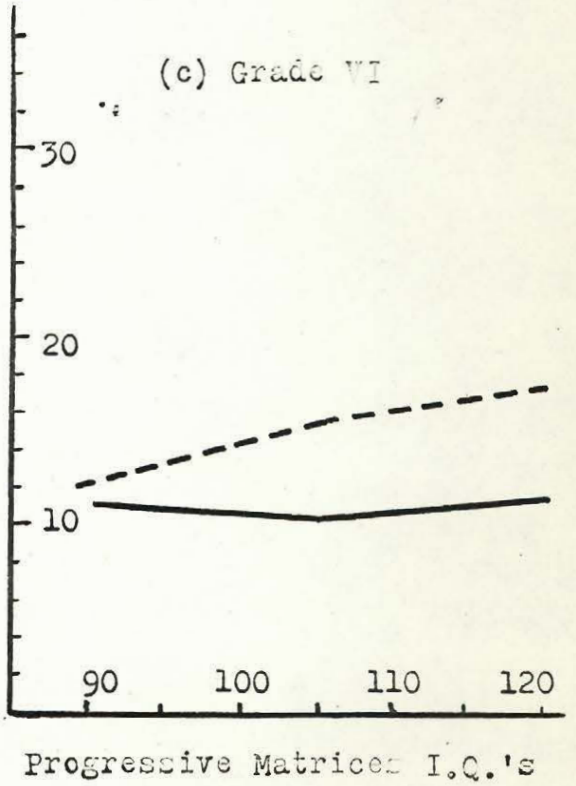
Fig. 2

Comparison of Scores
on the
Letter Series test (Revised)
with Otis I.Q.'s for
Grade V subjects
and Scores on the
Verbal Analogies test
(30 items)
with Otis and Matrices I.Q.'s
for Grade VI subjects

----- Experimental Group
——— Control Group







on the Verbal Analogies test did increase with increasing intelligence for subjects in the Control group, the differences between subgroups were not significant. The Verbal Analogies test did discriminate well between the subgroups of the Experimental group. The differences between all subgroups were significant at the .05 level. The correlation between Otis I.Q. and Verbal Analogies test scores for the Control group was .426 and for the Experimental group .724.

Results of the Progressive Matrices test were also available for this group. Progressive Matrices scores were converted into percentiles by using Raven's norms, and transformed into I.Q.'s with a mean of 100 and a standard deviation of 15. The Experimental and Control groups were, again, each divided into three subgroups (above 110, 100-110, and below 100), on the basis of Progressive Matrices I.Q.'s. The results are given in Table VI, and are very similar to those obtained from grouping by Otis results. The largest transfer effects occurred in the subgroup which contained the brightest subjects and the smallest transfer effects occurred in the subgroup which contained the dullest subjects. The correlation between Verbal Analogies test scores and Progressive Matrices I.Q.'s was .374 for the Control group and .548 for the Experimental group.

Grouping subjects by Progressive Matrices I.Q.'s,rather than Otis, results in one difference. With this method of grouping the Verbal Analogies test scores do not discriminate between the two highest subgroups of the Experimental group. In all other respects, however, the results are essentially similar when grouping is by either Progressive

Matrices or Otis I.Q.'s.

Next, a more difficult transfer condition, Non-Verbal Analogies practice followed by Verbal Analogies test, was administered to a group of 72 Grade VI pupils. Negative transfer effects were obtained for all except the brightest subjects. The results were difficult to interpret. Because initial scores were low (mean score of the Control group = 10.2), the maximum possible decrement in scores was small, and it was not possible to obtain significant negative transfer effects at any level of intelligence.

It seemed, however, that negative transfer effects in this difficult transfer condition might be of interest. In order to investigate this situation, the Verbal Analogies test was expanded to 40 items by the inclusion of 10 items so constructed that they might be solved by the application of general principles. When this test was administered to a group of Grade VII subjects, it was found that the mean score was 18.8. The correlation between Otis I.Q.'s and scores on the 40 item Verbal analogies test was .702.

The same transfer condition, that is the Non-Verbal analogies practice followed by the Verbal Analogies test (40 item), was used with 70 pupils in Grade VII as subjects. A small non-significant negative transfer effect was found for the total group, and transfer effects were uniformly small and negative when compared with Otis I.Q.'s. When subjects were divided into subgroups on the basis of Progressive Matrices I.Q.'s, an interesting trend emerged. The results are given in Table VII, which shows a positive transfer effect in subgroup I

(I.Q. above 110), and a negative transfer effect in the lower subgroups. Transfer effects, positive or negative, are not significant for any subgroup. Nevertheless, it appears that practice does have a significant effect because the Verbal Analogies test does discriminate between subgroups I and II of the Experimental group, but does not discriminate between any subgroups of the Control group.

The difference between grouping by Otis I.Q.'s and by Progressive Matrices I.Q.'s for this experimental condition was investigated further and the results are reported later in this chapter.

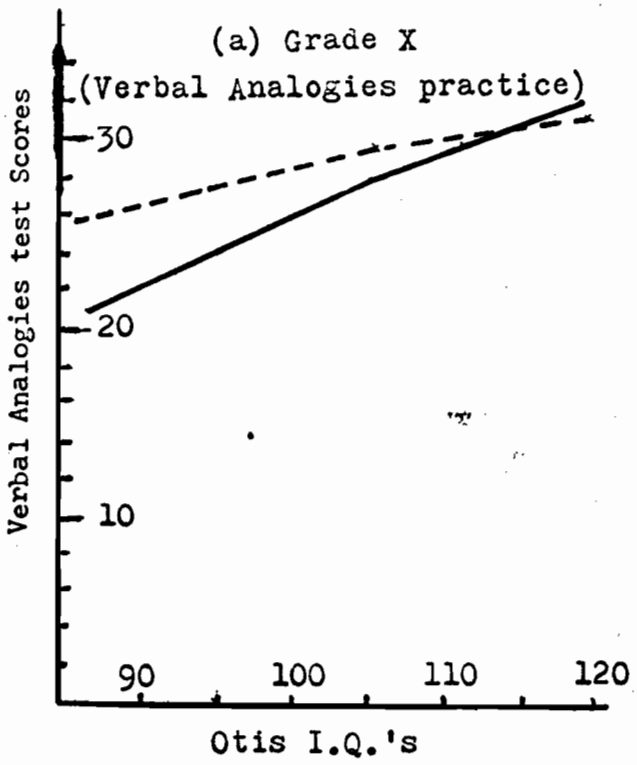
To explore transfer effects at higher levels of initial ability, where it was predicted that transfer would be easier, and not necessarily positively related to intelligence, the transfer condition involving Verbal Analogies practice, followed by Verbal Analogies test, was administered with 83 Grade X pupils as subjects. Subjects were matched, and grouped, on the basis of Otis I.Q.'s. The results are given in Table VIII and in Fig. 3a. The only significant transfer effect was found at the lowest level of intelligence (below 100). The Verbal Analogies test discriminated between the subgroups of the Control group but not between the subgroups of the Experimental group.

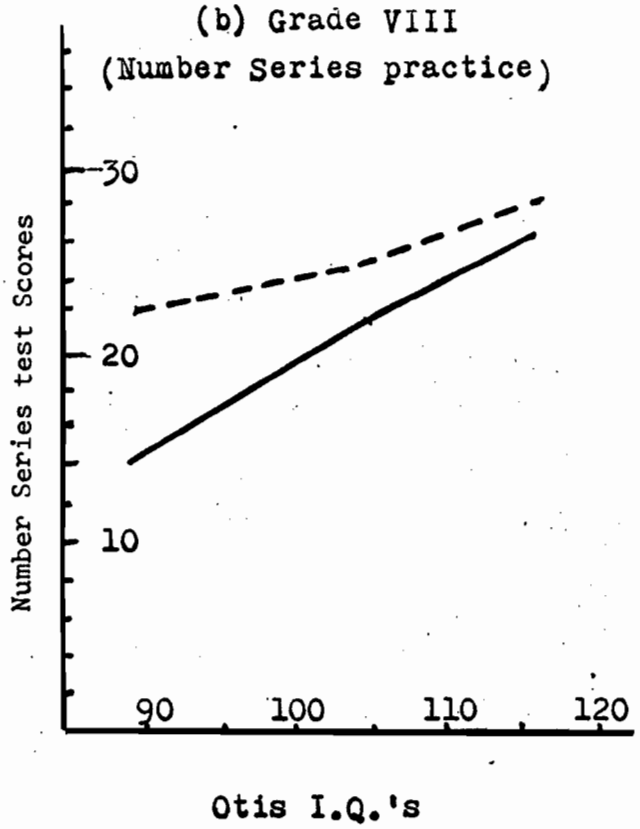
An easier transfer condition, Number Series practice followed by Number Series test, with 35 Grade VIII pupils as subjects, produced more significant but highly similar results. The results are given in Table IX and in Fig. 3b. Here again the largest transfer effect occurred at the lowest level of intelligence, and the Number Series test discriminated better between the subgroups of the Control group than of the Experimental group.

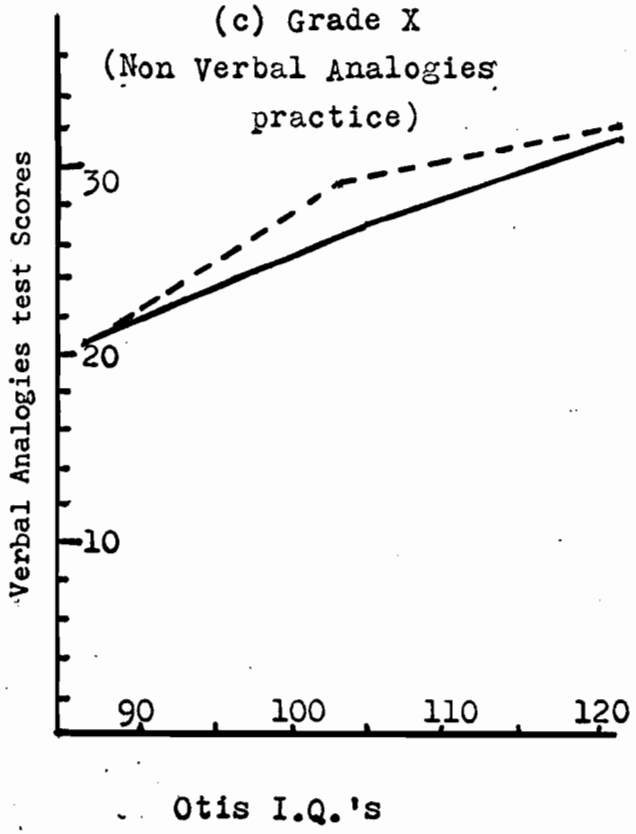
Fig. 3

Comparison of Scores
on the
Verbal Analogies test
for Grade X subjects
and on the
Number Series test
for Grade VIII subjects
with
Otis I.Q.'s

- - - - Experimental Group
——— Control Group







Finally, for this part of the investigation, a more difficult transfer condition was administered to subjects of high initial ability. The Non-Verbal Analogies practice followed by the Verbal Analogies test was administered to 32 Grade X subjects. The results are given in Table X and in Fig. 3c. The largest transfer effect occurred at the average level of intelligence with smaller transfer effects occurring at both higher and lower levels. These results are somewhat similar to those produced by the Number Series practice followed by the Letter Series test transfer condition with Grade VII subjects. Of particular interest is that the Verbal Analogies test discriminated well between the higher subgroups of the Control group and between the lower subgroups of the Experimental group.

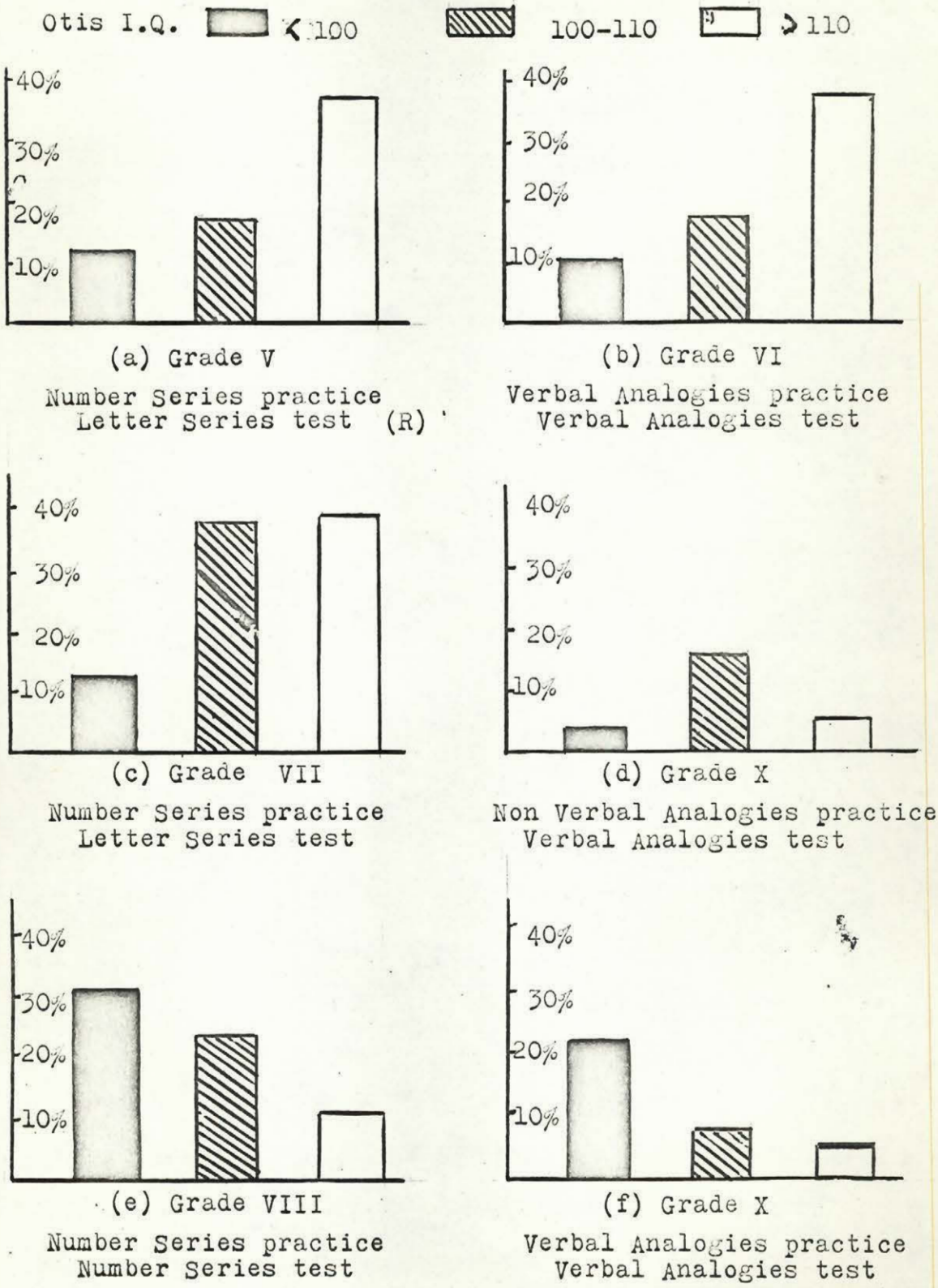
All of the foregoing results may be summarized in the following manner -- see Fig. 4.

(1) When subjects, whose level of performance on a measure of a particular ability is low, are given practice on the general principles necessary for the solution of items on a test of that ability, significant positive transfer effects are produced. When the material of the practice is different from that of the test, transfer is difficult and there is a positive relation between level of intelligence, as measured by conventional intelligence test, and amount of positive transfer.

(2) With subjects whose initial level of performance is higher, practice on material which is different from that of the test produces the largest positive transfer effects in the case of subjects of average intelligence. Smaller transfer effects occur at both higher and lower levels of intelligence.

Fig. 4

The relation between transfer percent and intelligence under six transfer conditions



(3) With subjects whose initial level of performance is high, practice on general principles, using material highly similar to that of the test, produces positive transfer effects which are inversely related to level of intelligence.

Each of the above statements is supported by results obtained from at least two different transfer conditions. These findings, essentially, confirm the hypothesis presented in the introduction.

Further research was directed toward the investigation of two hypotheses which emerged from a consideration of the results obtained during the first stage of the investigation.

First, it was observed that, for all groups of older subjects, all transfer conditions, which involved training on material which was not highly similar to that of the test, produced the smallest positive transfer effects in the lowest (below 100) I.Q. range. The same transfer conditions, when used with younger subjects, produced the largest positive transfer effects in the highest (above 110) I.Q. range. The intelligence test scores, however, obtained by the younger, brighter subjects, were identical with those obtained by the older, duller subjects. It appeared, therefore, that degree of brightness, rather than absolute "mental age", as measured by intelligence test scores, was the crucial variable in determining the amount of positive transfer effects.

To check this hypothesis, the results of the Grade V and VII pupils, who had been used as subjects in the Number Series practice followed by Letter Series test transfer condition, were re-examined. The results on the Letter Series test were compared to scores, rather than I.Q.'s,

obtained by these subjects on the Otis test. These results are given in Fig. 5a, which presents the relation between scores on the Letter Series test and scores on the Otis test for Grade V and VII Experimental and Control subjects. The Otis scores obtained by the Grade V and VII subjects overlap in the range from 34 to 54, with maximum overlap occurring in the range from 40-48. The mean scores of each group of subjects, in the range of maximum overlap, are given in Table XI. The mean Otis scores of the four groups do not differ significantly so that the groups may be considered to be of equivalent mental age (12 years and 10 months), as measured by the Otis test.

Although the mean score of the Grade V Control subjects on the Letter Series test is lower than that of the Grade VII Control subjects, the mean score of the Grade V Experimental subjects is higher than that of the Grade VII Experimental subjects. Furthermore, the transfer effect for the Grade V subjects is significant at the .01 level, while that of the Grade VII subjects is not significant.

To check this result with a different group of subjects and under slightly different transfer conditions, 50 Grade IV and 50 Grade VII pupils were selected as subjects. They were divided into Experimental and Control groups on the basis of scores obtained from both the Otis and the Progressive Matrices tests. A second Number Series practice was constructed so that the items were highly similar to those contained in the first Number Series practice. The Experimental groups were given the first Number Series practice under the standard conditions, including the coaching session, and were then given the second Number Series practice,

which was corrected by the examiner. Twenty minutes after the second Number Series practice had been completed, both Experimental and Control groups were given the Letter Series test (Revised).

The results for the Grade IV subjects, given in Fig. 5b, are highly similar to those obtained by the Grade V subjects who had been tested previously. The largest positive transfer effects were produced in the highest (above 115) I.Q. range. The correlation between Letter Series test scores and Otis scores for the Control group was .481, and for the Experimental group .809. The correlation between Letter Series test scores and Progressive Matrices scores for the Control group was .454, and for the Experimental group .797.

The results for the Grade VII subjects were similar to those obtained by previous testing of Grade VII groups, except that in the lowest I.Q. range (below 90) a significant negative transfer effect was found. This negative transfer effect is probably associated with the interference produced by the second Number Series practice. The correlation between Letter Series test scores and Otis scores for the Control group was .301 and for the Experimental group, .704. The correlation between Letter Series test scores and Progressive Matrices scores for the Control group was .535, and for the Experimental group .777.

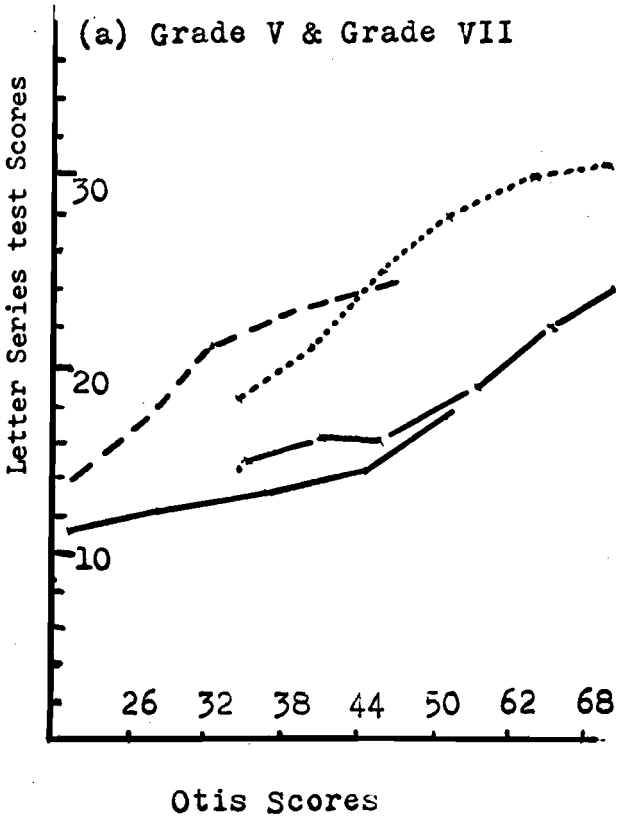
Fig. 5c shows the results of Grades IV and VII, Control and Experimental subjects, on the Letter Series test compared with scores on the Otis test. The Otis scores overlap in the range from 31-49 points, with maximum overlap occurring in the 34 to 43 point range. For subjects within this range the mean scores obtained by each group on the

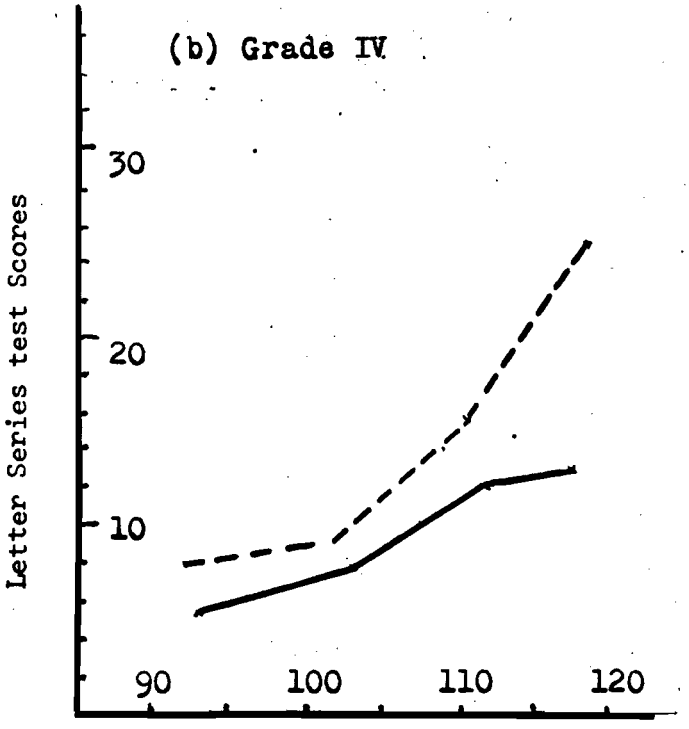
Fig. 5

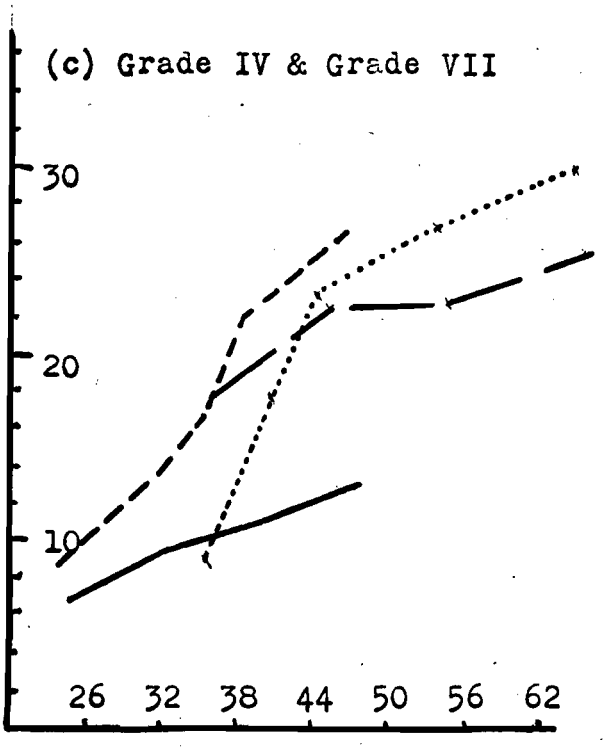
Comparison of Scores
on the
Letter Series test
with
Otis Scores
for Grade V and VII
and Grade IV and VII
Experimental and Control
subjects of the same
Mental Age

- - - - - Exp. Group (Gr. IV & V)
——— Control Gp.(Gr. IV & V)

..... Exp. Group (Gr. VII)
— — Control Gp.(Gr. VII)







Otis test, the second Number Series practice and the Letter Series test are given in Table XIVb. The differences between mean Otis scores are not significant and the differences between scores on the second Number Series are also not significant. The mean score of the Grade VII Control subjects on the Letter Series test is significantly higher than that of the Grade IV Control subjects. However, significant positive transfer effects were found in the case of the Grade IV subjects, but not in the case of the Grade VII subjects, so that there is no significant difference between the Series test scores of the Grade IV and VII Experimental subjects.

The above results suggest that the older, duller subjects have, perhaps because of a longer period of time in school, acquired the specific information necessary for the solution of particular problems on the Letter Series test. Without practice they obtain higher scores on the test than do the younger, brighter subjects. The older subjects are equal, or even superior, to the younger subjects in easy transfer situations in which the material, and level of difficulty of the practice and test activities, are highly similar. In more difficult transfer situations, involving the application of general principles to material which is different from that on which the training was given, the younger, brighter subjects are definitely superior.

The results of the "bright" and "dull" groups on the Otis test were examined, by means of an item analysis, but no items were found which would reliably differentiate between the groups. The scores of the groups on the Progressive Matrices test were also examined, and it was

found that the older, duller subjects obtained a mean score slightly higher than that obtained by the younger, brighter subjects. The greater ability of the bright subjects to transfer general principles from one type of material to a different type suggests an important qualitative difference between the intellectual performance of high and low I.Q. subjects. Conventional intelligence tests demonstrate quantitative differences between bright and dull in that bright students reach succeeding levels of test scores more rapidly than do dull subjects. Bright students also attain a higher eventual level. The findings presented above indicate that the manner in which succeeding levels are attained also differs for bright and dull. It is the greater "transferability" of the bright subjects which makes possible rapid intellectual development. The quality of "transferability" is not measured by conventional tests and can only be measured by a practice session followed by a test, as in the present study.

A second finding, from the general study, was selected for further investigation. It has been noted earlier that grouping subjects by Progressive Matrices I.Q.'s produced results which were somewhat different from those obtained when subjects were grouped by Otis I.Q.'s. This was especially obvious in the Non-Verbal analogies practice followed by Verbal analogies test transfer condition.

To obtain further information about the relation between transfer effects resulting from verbal and non-verbal practice and I.Q.'s obtained from both the Otis and Matrices tests, four additional groups of Grade VII subjects were tested. Both intelligence tests were administered to all subjects. Each group was then used as subjects for one of the following

transfer conditions:

(i) Verbal Analogies practice followed by Non-Verbal Analogies test.

(ii) Non-Verbal practice followed by Verbal test.

(iii) Verbal practice followed by Non-Verbal test.

(iv) Non-Verbal practice followed by Non-Verbal test.

Table XII gives the results for these four groups (Groups 2, 4, 5 and 6) and the two groups tested earlier (Groups 1 and 3). As before, significant positive transfer effects were produced when the material of the practice was similar in type to that of the test. No significant transfer effect was produced when the material of the practice was of a different type to that of the test.

Results on the Verbal Analogies test were available for four groups (Groups 1, 2, 3 and 4) and two transfer conditions (following Verbal practice and following Non-Verbal practice). Table XIII shows that there are consistent differences, between the Control and Experimental groups, in the correlations between Verbal Analogies test scores and I.Q.'s obtained from the Otis and the Matrices tests.

The subjects in Group 1 were of a lower age and educational level than the subjects in the other groups. The mean score of the Control subjects on the Verbal Analogies test was low. The correlation between Analogies test scores and both Otis and Matrices I.Q.'s was significant but low. The mean score of the Experimental group was significantly higher than that of the Control group. The correlation between Analogies test scores and both Otis and Matrices I.Q.'s was higher for the Experimental than for the Control group. For the Experimental group the cor-

relation between Analogies test scores and Otis I.Q.'s was higher than that between Analogies test scores and Matrices I.Q.

The subjects in Group 2 were older, in a higher Grade and the mean I.Q. was higher than that for the subjects in Group 1. The standard deviation of the I.Q.'s was small (s = 5.17). This high level of intelligence and the low variation in I.Q.'s probably contributed to the correlation coefficients generally found in this group. Nevertheless, the results show the same general trends as those for Group 1.

The subjects in Group 3 were of the same educational level as those in Group 2. The average I.Q. was, however, lower, and the standard deviation of the I.Q.'s larger (s = 11.28). For the Control group the correlation between scores in the Analogies test and Otis I.Q. was much higher than that between Analogies test scores and Matrices I.Q. For the Experimental group the correlation between Analogies test scores and Otis I.Q. was very similar to that of the Control group. The correlation between Analogies test scores and Matrices I.Q. was much higher for the Experimental than for the Control group.

The subjects in Group 4 had a lower mean I.Q. than those of Group 3, and a lower mean score on the Analogies tests. In all other respects, however, the results for Groups 3 and 4 are highly similar. With the exception of Group 2, the correlations between all tests for all Experimental groups are remarkably similar.

These results suggest that scores on the Verbal Analogies test, as demonstrated by Control group scores, are uniformly low for the younger, less intelligent subjects. Scores on the Analogies test increase

with increasing age, education and I.Q. As scores increase they become more closely associated with verbal abilities, as measured by the Otis tests. Transfer effects at higher levels of initial score, in particular those resulting from Non-Verbal practice, are closely associated with general intellectual ability, as measured by the Matrices test. The results presented above do not, in themselves, give adequate support for these suggestions because the differences in correlation between Control and Experimental groups, although large in most cases, were significant only in the case of Group 1.

In order to provide a clearer demonstration of the relation between Verbal Analogies test scores, without practice and following Non-Verbal practice, and scores obtained from both intelligence tests, it was necessary to select subjects who obtained a high score on one test and a low score on the other. Therefore, the I.Q.'s obtained by each subject in Groups 3 and 4 on the Otis and the Progressive Matrices test were compared.

For most subjects the Otis and Matrices I.Q.'s did not differ by more than 5 points. Large discrepancies, however, were observed in the case of some subjects. It was possible to select a group of 10 (5 Control and 5 Experimental) "high Otis low Matrices" subjects. These subjects all had Otis I.Q.'s above 105 and Matrices I.Q. below 100 with at least a 15 point difference between the two I.Q.'s. A similar group of 10 "low Otis high Matrices" subjects were selected. These subjects had Otis I.Q.'s below 100 and Matrices I.Q.'s above 105 and at least 15 points difference between the I.Q.'s.

The results for these 20 subjects are given in Table XIV. An analysis of variance for double classification showed that there was a significant interaction effect ($F = 11.87$; $df = 1.16$; $p < .01$), but no significant row or column effects. Subsequent "t" tests showed that in the Control the mean score of the "high Otis low Matrices" group was significantly higher than that of the "low Otis high Matrices" group. But Non-Verbal practice produced a significant negative transfer effect in the "high Otis low Matrices" group and a significant positive transfer effect in "low Otis high Matrices" group.

These results indicate that, for the Control group, scores on the Verbal Analogies test are closely associated with scores on the Otis test. Transfer effects produced by Non-Verbal practice are closely associated with scores on the Progressive Matrices test. These findings provide confirmation for the suggestion presented earlier that, without practice, scores on the Verbal Analogies test are closely associated with a measure of verbal abilities. Transfer effects produced by non-verbal practice are, however, closely associated with general reasoning ability.

In addition to the differential effects noted above, the general effect of practice for all transfer conditions investigated was to increase the correlations between scores on the ability tests and both the intelligence tests. Table XV gives the average correlation between scores on the Series and Analogies tests and I.Q.'s obtained from the Otis and Progressive Matrices tests. For all conditions the correlations are higher for the Experimental group, that is after practice, than for the Control groups without practice.

For some of the subjects the results of recent academic examinations were available. The marks obtained by each subject in all examinations were averaged to obtain a measure of academic achievement. Correlations between academic achievement and all tests used were calculated. The correlations between the Series and Analogies tests and academic achievement were, in every case, higher for the Experimental than for the Control groups. For the Experimental groups the average correlation between scores on the Letter Series test and academic achievement was .741, and the average correlation between the Verbal Analogies and academic achievement was .582. For the Control group, the corresponding correlations were .327 and .416, respectively. For all subjects the correlation between academic achievement and Otis I.Q.'s was .624. The correlation between academic achievement and Progressive Matrices I.Q.'s was .491. These results must be interpreted with caution. It seems likely, however, that transfer tests, such as those used in the present investigation, may provide a more valid method of assessing intellectual ability and of predicting academic achievement than do existing tests.

Chapter 4

Discussion and Implications

The results reported in the last chapter, together with the material presented in the introduction, provide a consistent picture of the relation between intelligence and transfer.

The relation between scores on the Otis test and scores on the Verbal Analogies test for all Control and Experimental subjects is demonstrated graphically in Fig.6(a). The scores of subjects who had received the 30 item test were adjusted so that they would be comparable to scores obtained from the 40 item test. The curves are based on the mean Analogies test scores for particular levels of performance on the Otis test. For Control and Experimental subjects, scores on the Verbal Analogies test showed a marked tendency to increase with increasing Otis scores, but the relation between level of performance on the two tests is not linear. Each curve shows a rapid rate of increase for a particular range of Otis scores, but the range differs for each group of subjects.

For the Control, i.e. the unpracticed subjects, the most rapid rate of increase occurs in the middle range, with slower rates of increase at the lower and higher range. This finding is consistent with the interpretation that rapid improvement on the Analogies test is associated with the application of general principles to provide the solution to particular items. The identification and application of

Fig. 6

(a) Average Scores on the Verbal Analogies test compared with Otis Scores for all subjects

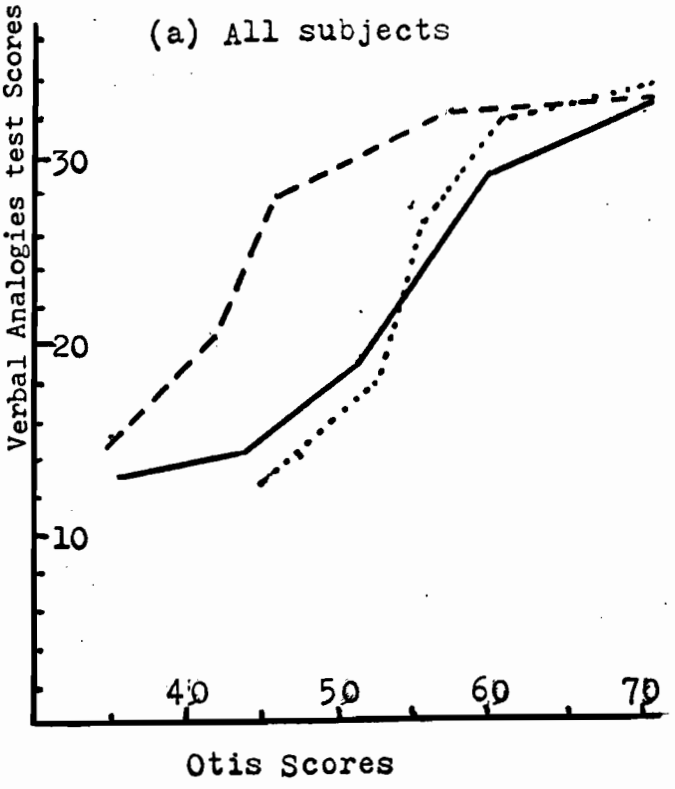
– – – – Exp. Gp. 1 Verbal practice

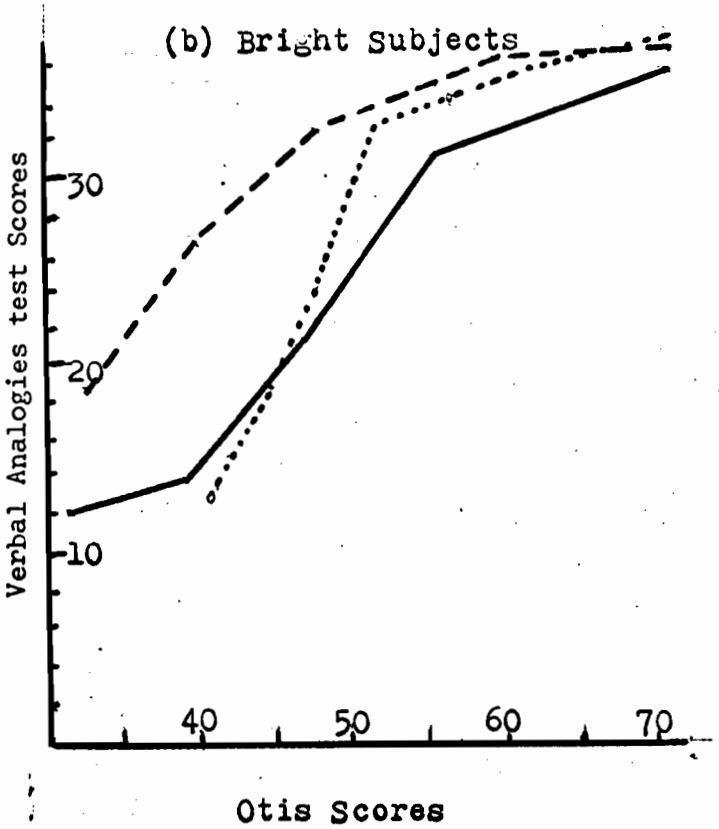
..... Exp. Gp. 2 Non Verbal practice

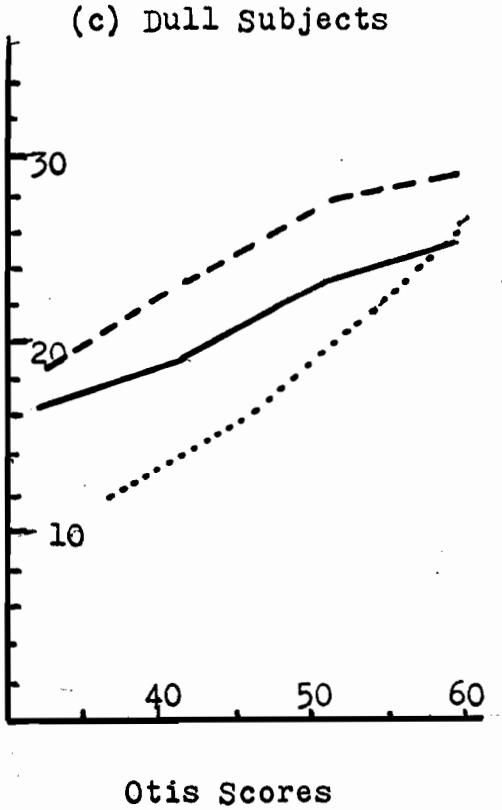
——— Control Gp.

(b) Bright (IQ >110) S's.

(c) Dull (IQ <90) S's.







the correct general principles requires some minimal intellectual level, as measured by the Otis test. Below this level the solution of items may be largely a matter of the rote memorization of the particular principles necessary to solve individual items. Consequently, rate of improvement in performance on the Analogies test is slow for subjects at the lowest level of Otis scores. Rate of improvement also tends to decrease at the higher level of Otis scores as an asymptotic level of Analogies test performance is reached. Improvement during this stage is probably related to knowledge of word meanings and of particular verbal relations.

The Experimental subjects who received practice on verbal material demonstrate a rapid increase in Analogies test performance at a lower level of Otis scores. Training on general principles with material similar to that of the test facilitates the transfer of these general principles to the problems presented by the test. The amount of improvement which can result from training on general principles is limited. The Experimental subjects approach an asymptotic level at a relatively low Otis level and there is little variation in Analogies test performance for the higher range of Otis scores.

The differences between scores of the Control and Experimental subjects on the Analogies test show that positive transfer effects, when compared to Otis scores, first increase and then decrease. The relation between Otis scores and transfer effects is positive for the lower range but negative for the higher range of Otis scores. The Experimental subjects who received practice on non-verbal material show

a rapid increase in Analogies test performance similar to that of the subjects who received training on verbal material. The increase, however, occurs at a higher level of Otis scores because transfer from non-verbal material is more difficult. Level of performance increases with results obtained from the Otis test for the higher range of Otis scores. Transfer effects, at first negative and then positive, are small. Consequently, it is difficult to demonstrate that transfer effects, produced by Non-Verbal practice, are related to scores on the Otis test. However, the correlation between level of performance on the Verbal Analogies test and Otis scores is higher for the Experimental than for Control subjects.

The results of the Control and Experimental subjects who received the Letter Series test are highly similar to those presented above. Level of performance on the Series test increased slowly, for the Control subjects, over the lower range of Otis scores. Over the higher range of Otis scores level of performance on the Series test increased rapidly with increasing Otis scores. The Experimental subjects who received the Number Series practice showed an early rapid increase in level of performance on the Series test with increasing Otis scores. The Experimental subjects reached an asymptotic level at a lower Otis range than did the Control subjects. Positive transfer effects were related to Otis scores only for the lower range of Otis scores.

The results of previous investigations on the relation between intelligence and transfer are consistent with these findings. In general, the studies which used young children as subjects reported a

positive relation between level of intelligence and positive transfer effects. Studies which used older children, or adults, as subjects reported no relation, or a negative relation between intelligence and transfer effects.

The results of the studies on the effect of practice on intelligence test scores are also consistent with the results of the present study. Alternative forms of the same test include the same general principles but change the actual content of the items. Practice thus gives training on general principles. When young subjects are given practice on alternative forms of a test which has a high ceiling, the transfer gains are correlated with initial score over a wide range of intelligence. On the other hand, with older subjects and in particular with subjects whose initial level on the test is high, transfer gains are inversely related to initial score.

Practice on general principles does not produce an increase in test scores for subjects whose initial score on the test is high. It is probable that practice on the particular principles and specific information required by the test would produce large transfer gains, related to intelligence, for subjects of high initial ability. The results obtained by Thorndike (1924) are compatible with this suggestion in that his subjects did show gains after academic training which stressed content rather than general principles. Furthermore, transfer gains following training were related to intelligence test scores.

It is interesting that Thorndike, whose subjects were in Grades X to XII, proposed an "identical elements" theory of transfer to account

for his results. For his subjects, transfer gains were associated with the transfer of specific content. Judd (1908), whose subjects were in Grades IV to VI, proposed a "generalization" theory of transfer because his subjects transferred general principles. The present formulation suggests that the two theories are not contradictory but are, essentially, complementary and refer to the operation of transfer at different initial levels of ability.

The results of the present study also suggest that the performance of "bright" students is not only quantitatively, but also qualitatively different from that of "dull" students. It was demonstrated that, under experimental transfer conditions, the performance of younger and older subjects of the same mental age was fundamentally different. Older dull subjects obtained higher initial scores on the Series and Analogies tests, but did not increase their level of performance after practice on material which was not highly similar to that of the test. This suggests that dull subjects attain any level of performance on an ability test as a result of small increments associated with directed training on material which is highly similar to that of the test. Younger bright subjects obtained lower initial scores on the tests but increased their level of performance significantly after practice on material which was not highly similar to that of the test. This suggests that brighter subjects attain levels of performance on ability tests as a result of extremely rapid improvement associated with the transfer of general principles from

a wide variety of experiences.

The relation between scores on the Verbal Analogies test for Control and Experimental bright (I.Q. above 110) subjects is given in Fig. 6b. The same relation for dull (I.Q. below 90) is given by Fig. 6c. Highly similar findings were reported earlier for the Letter Series test. The qualitative difference between the performance of bright and dull subjects was consistent for all transfer conditions.

Performance on the Series test showed a rapid increase at a lower range of Otis scores than did performance on the Analogies test. While this may be an artifact produced by the actual tests used, it is probable that some intellectual abilities do develop earlier than others. The investigation of performance on tests of particular intellectual abilities, before and after practice, may provide a more comprehensive picture of the development of intelligence than is possible with current methods of investigation.

In addition to the investigation of the development of intelligence, the present research has implications for the construction of intelligence tests. From a practical point of view it has been suggested that coaching (James, 1953) and practice (Ortar, 1960) increase the validity of intelligence test scores. These authors state that practice or coaching gives subjects who have a limited educational background an opportunity to become familiar with the material of the test. That practice is of value is also suggested by theoretical considerations. Many definitions of intelligence include or at least imply the capacity to use previously acquired information in

a novel situation. Practice provides an opportunity to acquire general principles and specific content, and these acquisitions may then be used to provide the solution to items on a later test. A practice session followed by a test gives a measure of the extent to which the information of the practice is used in the solution of items on the test.

The general findings concerning transfer are of importance because, if the practice session is to be of value, the transfer from practice to test must present an appropriate level of transfer difficulty. Unless transfer effects, resulting from practice, are correlated with intelligence,the effect of practice will be to increase the scores of the least intelligent subjects but not the scores of the most intelligent subjects. Consequently, practice would decrease rather than increase the validity of the test. The type of practice which will produce the appropriate level of transfer difficulty will vary with the age of the subjects. For young subjects, the practice should consist of items which present the same general principle by means of material which is highly similar to that of the later test. (For example, Verbal Analogies practice followed by a Verbal Analogies test). For the older subjects the practice should include items which present the same general principles by means of material which is dissimilar to that of the test. (For example, Non-Verbal Analogies practice followed by a Verbal Analogies test). For the oldest subjects the practice should contain items which have a similar content but different general principles to those of the test.

(For example, practice in the discovery of word meanings followed by a Verbal Analogies test). The practical importance of these suggestions on the construction of alternative test forms for use with various age levels is obvious.

Previous studies also report that scores on tests which followed practice correlated more highly with measures of academic achievement than did scores on tests without practice. The results of the present study confirm this finding. If, as was proposed earlier, transfer is a general phenomenon of which learning is a special case, it is probable that test scores which are determined in part by transfer gains do measure learning capacity. The scores on the Letter Series test following Number Series practice correlated highly with general academic achievement. It is probable that further research may produce practice and test combination which will predict achievement better than do existing tests.

The findings of the present study have implications for educational practices and procedures as well. It has been demonstrated that bright subjects have a capacity which is not only quantitatively but also qualitatively different from that of dull subjects. Dull subjects require instruction which presents similar material in small step sequence. Such training is the only type which can be of benefit to them. Bright subjects, however, have the capacity to relate information from a wide variety of material to present problems. A more general type of training, stressing principles which can be applied in many situations, rather than specific content, would be of most

benefit to these brighter subjects. Current educational practices, in particular programmed instruction, appear to be designed especially to suit the limited capacity of the dull. Methods which stress "guided discovery", with wide areas of application, seem much better suited to the capacity of the brighter students. The "inquiry training" suggested by Suchman (1960) appears to be a promising step in this direction.

It is not known, at this time, if the effect of practice persists over a long period of time. It seems unlikely that the limited period of training used in the present study produces improvement in performance for more than a few weeks, or months, at the most. It does seem likely, in view of the previously reported studies of Bunch (1936) and Vernon (1954), that a longer period of training will produce improved performance over a longer period of time, and which may even be permanent. If future investigation demonstrates that this is, in fact, the case, it seems possible that methods of training may be devised which will produce earlier development of intellectual abilities and increase the eventual level of these abilities. That such training is possible has been explicitly stated by Hunt (1961). The present approach might provide one method by which such improvement might be realized.

It is obvious that the research included in this report does not provide a complete account of the relation between intelligence and transfer. Consistent results have been obtained by using a combination of practice and test within a certain limited area. A tentative

formulation has been presented which includes the results of this study, and which is consistent with the results of earlier studies. Further research is necessary to replicate the most important findings with other groups of subjects and in other areas of intellectual ability. The exploration of the implications of this study requires further research. The findings of the present study suggest that further investigation of the relation between intelligence and transfer may produce results of considerable practical and theoretical interest.

Summary

Previous research on the relation between intelligence and transfer is limited. Most investigations of transfer have attempted to maximize positive transfer effects and have not been concerned with individual differences in transfer. The few studies on the relation between intelligence and transfer report results which are both inconsistent and inconclusive.

The present research sought to demonstrate that under transfer conditions of appropriate difficulty a positive relation between transfer effects and intelligence would occur. Under less difficult conditions of transfer the relation would be inverse, with the subjects at the lowest level of intelligence obtaining the largest positive transfer effects.

Experimental subjects were given practice on the general principles necessary for the solution of items on an ability test. The ability test was later administered to Experimental and non-practiced Control subjects. Transfer effects were demonstrated by the difference in scores between the two groups. When the material of the practice was not highly similar to that of the test, and the initial level of ability as demonstrated by Control group scores was low, the amount of positive transfer was closely associated with level of intelligence, as measured by both a verbal and a non-verbal intelligence test. When older subjects, with higher initial scores, were given practice on general principles with material highly sim-

ilar to that of the test, a negative relation between level of intelligence and amount of positive transfer was found.

A further finding of this study was that transfer effects were more closely associated with degree of brightness, as measured by I.Q., than with intelligence test scores. Bright and dull subjects of the same mental age were used as subjects in a transfer condition involving practice on material different from that of the later ability test. The older dull subjects obtained higher initial scores on the ability test than did the younger bright subjects. The bright subjects, however, showed significant positive transfer effects as a result of practice, but the dull subjects did not.

When subjects were given practice on non-verbal material followed by a verbal test, the resulting transfer effects were small. There was a relation between transfer effects produced in this condition with scores on the non-verbal, but not the verbal, intelligence test.

The results of the present study were combined with results of previous investigations to provide a consistent picture of the relation between intelligence and transfer. Some suggestions were offered concerning the implications of these results for the investigation of the development of intellectual abilities. It was also pointed out that these results have implications for the practical assessment of intelligence and for educational procedures. Further research is necessary but the findings of the present study indicate that the exploration of the relation between intelligence and transfer is of theoretical and practical interest.

Table I

(a) Mean scores of the Control and Experimental (Grade VII) subjects on the Letter Series test. Subjects are matched on Otis I.Q. The Experimental group received the Number Series practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	L.T. Mean	L.T. S	N	I.Q. Mean	L.T. Mean	L.T. S	Score Diff.	t	p**
Total	64	109.9	18.7	6.83	64	109.8	25.5	6.15	6.8 31.9%	5.86	.001
S.G.I >120	14	125.5	24.6	6.88	14	126.1	30.2	4.23	5.6 36.4%	2.39	.05
II 110-119	21	114.8	19.0	6.62	21	113.9	27.5	4.98	8.5 40.5%	4.59	.001
III 100-109	15	103.7	15.7	4.64	15	104.3	24.7	4.07	9.0 37.0%	5.45	.001
IV <100	14	94.0	15.4	5.08	14	93.6	18.6	5.15	3.2 13.0%	2.18	.05

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups in the Letter Series test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	5.6	2.33	.05	2.7	1.68	n.s.
II & III	3.3	1.71	.05*	2.8	1.79	.05*
III & IV	0.3	0.16	n.s.	6.1	3.43	.01

* one-tailed tests.

** In this and in subsequent tables a p value of .001 indicates that the level of significance is less than .001. This applies to all other values as well.

Table II

(a) Mean scores of the Control and Experimental (Grade VI) subjects on the Letter Series test. Subjects are matched on Otis I.Q. The Experimental group received the Number Series practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	L.T. Mean	L.T. S.	N	I.Q. Mean	L.T. Mean	L.T. S.	Score Diff.	t	p
Total	48	105.3	15.1	5.82	48	105.1	25.9	5.21	10.8 43.4%	13.5	.001
S.G.I >120	4	123.2	23.0	4.60	4	126.2	32.5	2.07	9.5 55.9%	3.28	.01*
II 110-119	16	112.2	15.1	5.79	16	112.4	29.8	3.54	14.7 59.0%	7.21	.001
III 100-109	15	105.1	15.4	4.31	15	104.9	24.9	4.55	9.5 38.6%	5.65	.001
IV <100	13	91.5	12.5	2.77	13	91.5	20.5	4.99	7.7 28.0%	4.59	.001

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Letter Series test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	7.9	2.41	.05	2.7	1.65	n.s.
II & III	-0.3	-	n.s.	4.9	3.13	.01
III & IV	2.9	1.86	.05*	4.4	2.35	.05

* one-tailed tests.

Table III

(a) Mean scores of the Control and Experimental (Grade V) subjects on the Letter Series test. Subjects are matched on Otis I.Q. The Experimental group received the Number Series practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	L.T. Mean	L.T. S	N	I.Q. Mean	L.T. Mean	L.T. S	Score Diff.	t	p
Total	73	109.4	13.6	5.82	85	108.7	20.0	6.78	6.4 24.2%	6.27	.001
S.G.I >120	15	127.1	17.1	7.05	17	126.8	24.7	5.82	7.6 33.2%	3.21	.01
II 110-119	18	113.6	14.4	5.26	18	114.5	23.0	4.47	8.6 33.6%	5.15	.001
III 100-109	19	105.8	12.9	4.04	27	105.7	19.8	6.63	6.9 25.5%	4.37	.001
IV <100	21	96.4	11.1	2.10	23	94.2	14.3	6.26	3.2 11.1%	2.27	.05

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Letter Series test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	2.7	1.18	n.s.	1.7	0.95	n.s.
II & III	1.5	0.94	n.s.	3.2	1.93	.05
III & IV	1.8	1.70	.05*	5.5	3.01	.01

*one-tailed tests.

Table IV

(a) Mean scores of the Control and Experimental (Grade V) subjects on the Letter Series test (Revised). Subjects are matched on Otis I.Q. The Experimental group received the Number Series practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	L.T. Mean	L.T. S	N	I.Q. Mean	L.T. Mean	L.T. S	Score Diff.	t	p
Total	39	104.6	9.2	5.82	35	105.6	16.3	5.73	7.1 23.1%	5.29	.001
S.G.I. >115	4	120.2	10.2	3.10	6	120.3	23.7	3.50	13.5 43.6%	5.57	.001
II 110-114	7	112.1	11.0	6.30	5	111.4	19.8	3.33	8.8 30.3%	2.61	.05
III 100-109	18	106.1	8.6	4.63	17	104.6	14.4	5.30	5.8 18.5%	3.35	.01
IV <100	10	90.6	8.5	5.47	7	91.3	12.3	5.67	3.8 12.1%	1.31	n.s.

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Letter Series test (Revised).

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	-0.8	-	n.s.	3.9	1.79	.05*
II & III	2.4	1.00	n.s.	5.4	2.07	.05
III & IV	0.1	-	n.s.	2.1	0.83	n.s.

*one-tailed tests.

Table V

(a) Mean scores of the Control and Experimental (Grade VI) subjects on the Verbal Analogies test (30 item). Subjects are matched on Otis I.Q. The Experimental group received the Verbal Analogies practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	Score Diff.	t	p
Total	37	100.1	11.3	3.62	35	100.9	14.9	4.19	3.6 19.2%	3.87	.001
S.G.I. >110	9	114.9	13.0	4.79	9	116.6	19.2	3.89	6.2 36.5%	2.86	.02
II 100-109	9	104.4	12.0	3.46	11	103.4	15.2	3.10	3.2 17.8%	2.00	.05
III <100	19	91.1	10.2	2.26	15	90.0	12.2	2.70	2.0 10.1%	2.25	.05

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Verbal Analogies test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	1.0	0.48	n.s.	4.0	2.34	.05
II & III	1.8	1.35	n.s.	3.0	2.38	.05

Table VI

(a) Mean scores of the Control and Experimental (Grade VI) subjects on the Verbal Analogies test.. Subjects are matched on Progressive Matrices I.Q. The Experimental group received the Verbal Analogies practice.

	Control				Experimental						
P.M. I.Q. Range	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	Score Diff.	t	p
Total	35	105.5	10.8	3.50	35	105.8	14.9	4.19	4.1 21.4%	4.31	.001
S.G.I. >110	10	119.4	11.6	4.68	12	121.6	17.2	4.31	5.6 30.4%	2.79	.02
II 100-109	16	105.4	10.4	3.42	14	102.6	15.0	3.23	4.6 23.5%	3.71	.01
III <100	9	90.2	11.0	2.07	9	89.7	12.1	2.14	1.1 5.8%	1.07	n.s.

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Verbal Analogies test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	1.2	0.75	n.s.	2.2	1.41	n.s.
II & III	-0.6	-	n.s.	2.9	2.23	.05

Table VII

(a) Mean scores of the Control and Experimental (Grade VII) subjects on the Verbal Analogies test (40 item). Subjects are matched on Progressive Matrices I.Q. The Experimental group received the Non-Verbal Analogies practice.

	Control				Experimental						
P.M. I.Q. Range	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	Score Diff.	t	p
Total	35	102.4	19.6	4.85	35	102.1	18.7	5.05	-0.9	-	n.s.
S.G.I. >110	9	116.8	21.2	4.33	6	117.9	23.5	4.33	2.3	0.94	n.s.
II 100-109	18	101.4	18.9	4.45	21	99.3	18.5	3.82	-0.4	-	n.s.
III <100	8	93.2	19.2	5.63	8	92.4	15.6	5.64	-3.6	1.16	n.s.

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Verbal Analogies test (40 item).

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	2.3	1.24	n.s.	5.0	2.63	.02
II & III	-0.3	-	n.s.	2.9	1.55	n.s.

Table VIII

(a) Mean scores of the Control and Experimental (Grade X) subjects on the Verbal Analogies test (40 item). Subjects are matched on Otis I.Q. The Experimental group received the Verbal Analogies practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	N	I.Q. Mean	V.A.T. Mean	V.A.T S	Score Diff.	t	p
Total	56	106.7	26.9	4.31	27	101.8	27.7	4.01	0.8 6.1%	0.79	n.s.
S.G.I. >110	25	121.6	31.5	4.27	9	121.2	31.0	3.08	0.5 5.9%	-	n.s.
II 100-109	15	103.1	26.2	3.81	7	102.7	28.1	3.76	1.9 7.8%	1.04	n.s.
III <100	16	86.7	20.4	4.12	11	85.4	24.8	4.57	4.4 22.9%	2.51	.02

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Verbal Analogies test (40 item).

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	5.3	3.84	.01	2.9	1.65	n.s.
II & III	3.8	2.60	.05	3.3	1.52	n.s.

Table IX

(a) Mean scores of the Control and Experimental (Grade VIII) subjects on the Number Series test. Subjects are matched on Otis I.Q. The Experimental group received the Number Series practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	Mean	S	N	I.Q. Mean	Mean	S	Score Diff.	t	p
Total	17	108.5	22.5	5.27	18	107.1	26.1	3.23	3.6 20.6%	2.38	.05
S.G.I >110	8	116.3	26.3	3.76	9	114.2	27.8	2.82	1.5 10.9%	0.88	n.s.
II 100-109	7	104.7	20.7	4.82	6	106.7	25.3	3.07	4.6 23.8%	1.85	.05*
III <99	2	91.0	14.0	2.00	3	95.3	22.3	4.83	8.3 31.9%	1.79	n.s.

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Number Series test.

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	5.6	2.33	.05	2.5	1.45	n.s.
II & III	6.7	1.69	n.s.	3.0	1.00	n.s.

*one-tailed tests.

Table X

(a) Mean scores of the Control and Experimental (Grade X) subjects on the Verbal Analogies test (40 item). Subjects are matched on Otis I.Q. The Experimental group received the Non-Verbal Analogies practice.

	Control				Experimental						
Otis I.Q. Range	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	N	I.Q. Mean	V.A.T. Mean	V.A.T. S	Score Diff.	t	p
Total	56	106.7	26.9	4.31	32	105.5	27.6	4.76	0.7 5.3%	0.70	n.s.
S.G.I. >110	25	121.6	31.5	4.27	10	122.7	31.9	3.68	0.4 4.7%	0.25	n.s.
II 100-109	15	103.1	26.2	3.81	14	101.8	28.3	5.07	2.1 15.2%	1.20	n.s.
III < 99	16	86.7	20.4	4.12	8	89.4	21.1	3.21	0.7 3.5%	0.40	n.s.

(b) Differences between the mean scores of the subgroups of the Control and Experimental groups on the Verbal Analogies test (40 item).

	Control			Experimental		
Between Subgroups	Score Diff.	t	p	Score Diff.	t	p
I & II	5.3	3.84	.01	3.6	1.82	.05*
II & III	3.8	2.60	.05	7.2	3.67	.01

*one-tailed tests.

Table XI

(a) Comparison of the Mean Scores on the Otis and Letter Series tests for Grade V and VII Control and Experimental subjects. The Experimental subjects received the Number Series practice.

	Control			Experimental					
	N	Otis Mean	L.T. Mean	N	Otis Mean	L.T. Mean	L.T. Diff.	t	p
Gr. VII	6	43.6	16.3	5	44.8	20.2	3.9	1.62	n.s.
Gr. V	14	41.6	13.8	11	43.2	22.4	8.6	3.05	.01
		Diff.	2.5		Diff.	2.2			
		t	1.42		t	1.38			
		p	n.s.		p	n.s.			

(b) Comparison of the Mean Scores on the Otis, Number Series, and Letter Series tests for Grade IV and VII Control and Experimental subjects. The Experimental subjects received the Number Series practice.

	Control			Experimental						
	N	Otis Mean	L.T. Mean	N	Otis Mean	N.S. Mean	L.T. Mean	L.T. Diff.	t	p
Gr. VII	5	37.8	18.8	10	41.3	20.2	19.8	1.0	1.17	n.s.
Gr. IV	15	37.3	10.1	11	38.4	18.8	19.3	9.2	3.77	.01
		Diff.	8.7		Diff.	1.4	0.6			
		t	2.53		t	0.76	0.42			
		p	.05		p	n.s.	n.s.			

Table XII

Comparison of the Mean Scores on the Analogies tests for six groups of Control and Experimental subjects under four different conditions of transfer.

			Control			Experimental					
Transfer Condition	Gr.	Gp.	N	A.T. Mean	A.T. S.	N	A.T. Mean	A.T. S.	A.T. Diff.	t	p
Verbal Practice	VI	1	35	11.3	3.50	35	14.9	4.19	3.6	3.87	.001
Verbal Test	VII	2	36	20.8	4.74	36	23.5	3.61	2.7	2.67	.01
Non-Verbal Practice	VII	3	35	19.6	4.85	35	18.7	5.05	-0.9	0.71	n.s.
Verbal Test	VII	4	17	16.3	5.38	17	16.0	3.94	-0.3	-	n.s.
Verbal Practice Non-Verbal Test	VII	5	30	16.7	4.11	30	17.5	4.87	0.8	0.63	n.s.
Non-Verbal Practice Non-Verbal Test	VII	6	30	16.7	4.11	30	20.1	2.53	3.4	3.78	.01

Table XIII

Correlations between Otis and Matrices I.Q.'s, and between I.Q.'s obtained from each test and scores on the Verbal Analogies test for four groups of Control and Experimental subjects.

	Control					Experimental				
Gp.	Otis Mean I.Q.	P.M. Mean I.Q.	$r_{Otis\ \&\ P.M.}$	$r_{Otis\ \&\ A.T.}$	$r_{P.M.\ \&\ A.T.}$	Otis Mean I.Q.	P.M. Mean I.Q.	$r_{Otis\ \&\ P.M.}$	$r_{Otis\ \&\ A.T.}$	$r_{P.M.\ \&\ A.T.}$
1	100.1	105.5	.684	.426	.374	100.9	105.8	.543	.724	.548
2	112.8	110.4	.356	.491	.341	112.2	111.2	.425	.531	.446
3	105.5	103.4	.528	.731	.216	104.5	102.1	.564	.728	.537
4	98.7	101.4	.463	.811	.391	99.1	101.8	.449	.691	.671

Table XIV

Comparison of Mean Scores on the Verbal Analogies test for Control and Experimental subjects who obtained high I.Q.'s on one intelligence test and low I.Q.'s on the other. The Experimental subjects received the Non-Verbal Analogies practice.

	Control	Exp.			
Group	Mean Score V.A.T.	Mean V.A.T.	Score Diff.	t	p
1. High Otis Low Matrices	24.5	17.8	-6.7	2.50	.05
2. Low Otis High Matrices	16.2	20.8	+4.6	2.44	.05
Score Diff.	8.3	3.0			
t	3.44	1.26			
p	.01	n.s.			

Table XV

Correlations between I.Q.'s obtained from the Otis and Progressive Matrices tests and scores on the Series and the Analogies tests on Control and Experimental subjects.

Condition	Control		Experimental	
	Mean r_{Otis}	Mean $r_{P.M.}$	Mean r_{Otis}	Mean $r_{P.M.}$
Number Series Practice Letter Series Test	.319	.508	.740	.787
Verbal Analogies Practice Verbal A Test	.590	.351	.758	.548
Non-Verbal Analogies P Verbal A Test			.745	.561

References

Adkins, D.C. The effect of practice on intelligence test scores. J. educ. Psychol., 1937, 28, 222-231.

Allison, R.B. Learning Parameters and Human Abilities. Princeton, N.J. Educational Testing Services. Technical Report. 1960.

Anastasi, A. Psychological Testing (Second Edition). New York: The MacMillan Company, 1961.

Andreas, B.G. Experimental Psychology. New York: John Wiley & Sons, Inc., 1960.

Barlow, M.C. Transfer of training in reasoning. J. educ. Psychol., 1937, 28, 122-128.

Bialer, I. Primary and secondary stimulus generalization as related to intelligence level. J. exp. Psychol., 1961, 62, 395-402.

Brogden, W.J. In Stevens (Ed.) Handbook of Experimental Psychology. New York: John Wiley & Sons, Inc., 1951.

Brooks, F.D. The transfer of training in relation to intelligence. J. educ. Psychol., 1924, 15, 413-422.

Broyler, C., Thorndike, E.L., and Woodyard, E. A second study of mental discipline in High School studies. J. educ. Psychol., 1927, 18, 377-404.

Bruce, R.W. Condition of transfer of training. J. exp. Psychol., 1933, 16, 343-361.

Bruner, J. The Process of Education. Cam. Mass. Harvard Univer. Press, 1960.

Bunch, M.E. The amount of transfer in rational learning as a function of time. J. comp. Psychol., 1936, 22, 325-337.

References (Cont'd)

Burnett, A., Beach, H.D., and Sullivan, A. Intelligence in a restricted environment. Canad. Psychologist, 1963, 4, 126-136.

Burt, C. The structure of the mind: a review of the results of factor analysis. Brit. J. educ. Psychol., 1949, 19, 110-111, 174-199.

Buswell, G.T. Patterns of thinking in solving problems. Univ. Calif. Publ. Educ., 1956, 12, 63-148.

Carroll, H.A. Generalization of bright and dull children; a comparative study with special reference to spelling. J. educ. Psychol., 1930, 21, 488-499.

Cattell, R.B. The theory of fluid and crystallized general intelligence: a crucial experiment. J. educ. Psychol., 1963, 54, 1-22.

Colver, R.M., and Spielberger, C.D. Further evidence of a practice effect on the Miller Analogies Test. J. appl. Psychol., 1961, 45, 126-127.

Cranwell, C.W. Transfer in problem solving as related to the type of training. J. gen. Psychol., 1956, 47, 223-234.

Dempster, J.J.B. Symposium on the effects of coaching and practice in intelligence tests: III. Southampton investigation and procedure. Brit. J. educ. Psychol., 1954, 24, 1-4.

Dennis, W., & Dennis, M.G. Infant development under conditions of restricted practice and minimum social stimulation. Genet. Psychol. Monogr., 1941, 23, 149-155.

Dennis, W., and Najarian, P. Infant development under environmental handicap. Psychol. Monogr., 1957, 71, No. 436.

References (Cont'd)

Duncan, Carl P. Transfer of motor learning as a function of first task learning and inter task similarity. J. exp. Psychol., 1953, 45, 1-11.

Ferguson, G.A. On learning and human ability. Canad. J. Psychol., 1954, 8, 95-112.

Ferguson, G.A. On transfer and the abilities of man. Canad. J. Psychol., 1956, 10, 121-131.

French, J.W. Manual for kit of selected tests for reference aptitude and achievement factors. Princeton, N.J., Educational Testing Services. 1954.

Furneau, W.D. The Nufferno Manual of Speed Tests and the Nufferno Manual of Level Tests. (Published by the Inst. of Psychiatry and distributed by the National Council of Educational Research, 1956.)

Gagne, R.M., Foster, H., and Crowley, M.E. The measurement of transfer of training. Psychol. Bull., 1948, 45, 97-130.

Gagne, R.M., & Bolles, R.C. In DeCecco (Ed.) Human Learning In The School. New York: Holt, Rinehart & Winston, 1963.

Garrett, H.E. A developmental theory of intelligence. Amer. Psychologist, 1946, 1, 372-378.

Gibson, E.J. Retroactive inhibition as a function of degree of generalization between tasks. J. exp. Psychol., 1941, 28, 93-115.

Goldfarb,W. Psychological privation in infancy and subsequent adjustment. Amer. J. Orthopsychiat., 1945, 15, 247-255.

References (Cont'd)

Guilford, J.P. The structure of intellect. Psychol. Bull., 1956, 53, 267-293.

Halserud, G.M. and Meyers, S. The transfer value of given and individually derived principles. J. educ. Psychol., 1958, 49, 293-298.

Hamilton, C.E. The relationship between length of interval separating two learning tasks and performance on the second task. J. exp. Psychol., 1950, 40, 613-621.

Harlow, H.F. The formation of learning sets. Psychol. Rev., 1949, 56, 363-376.

Hebb, D.O. The Organization of Behavior. New York: John Wiley & Sons, Inc., 1949.

Hendrickson, G., and Schroeder, W. Transfer of training in learning to hit a submerged target. J. educ. Psychol., 1941, 32, 205-213.

Hendrix, G. A new clue to the transfer of training. Elem. sch. J., 1947, 48, 197-208.

Hilgard, E.R., Irvine, R.P., and Whipple, J.E. Rote memorization, understanding, and transfer: An extension of Katona's card trick experiments. J. exp. Psychol., 1953, 46, 288-292.

Hilgard, E.R., Edgren, R.D., and Irvine, R.P. Errors in transfer following learning with understanding. Further studies with Katona's card trick experiments. J. exp. Psychol., 1954, 47, 457-464.

Holloway, H.D. Effects of training on the S.R.A. Primary Mental Abilities (Primary) and W.I.S.C. Child Develpm., 1954, 25, 253-263.

Hunt, J.McV. Intelligence and Experience. New York: The Ronald Press Co., 1961.

References (Cont'd)

James, H.E. The transfer of training. Brit. J. Psychol., 1930, 20, 322-338.

James, W.S. Symposium on the effects of coaching and practice in intelligence tests: II. Coaching for all recommended. Brit. J. educ. Psychol., 1953, 23, 155-162.

Judd, C.H. The relation of special training to general intelligence. Educ. Review, 1908, 36, 28-42.

Katona, G. Organizing and memorizing: studies in the psychology of learning and teaching. New York: Columbia Univ. Press, 1940.

Kittell, J.E. An experimental study of the effect of external direction during learning on transfer and retention of principles. J. educ. Psychol., 1957, 48, 391-405.

Kuenne, M.R. Experimental investigation of the relation of language to transposition behavior in young children. J. exp. Psychol., 1946, 36, 471-490.

Lefever, D.W. In Buros (Ed.) The Fifth Mental Measurements Yearbook. Highland Park, N.J., The Gryphon Press, 1959.

Lorge, I., and Thorndike, R.L. Examiner's Manual, The Lorge Thorndike Intelligence Tests. Boston: Houghton Mifflin Co., 1956.

Luchins, A.S. Mechanization in problem solving: the effect of Einstelling. Psychol. Monogr., 1942, 54, No. 248.

MacArthur, R.S., and Elley, W.B. The Reduction of socioeconomic bias in intelligence testing. Brit. J. educ. Psychol., 1963, 33, 107-119.

References (Cont'd)

MacKay, G.W., & Vernon, P.E. The measurement of learning ability. Brit. J. educ. Psychol., 1963, 32, 177-186.

McGeoch, J.A. The Psychology of Human Learning. New York: Longmans Green and Co., 1942.

McGeoch, J.A., & Irion, A.L. The Psychology of Human Learning. New York: Longmans Green and Co., 1952.

Mandler, G. Transfer of training as a function of degree of response overlearning. J. exp. Psychol., 1954, 47, 411-417.

Morrisett, L., and Hovland, C.T. A comparison of three varieties of training in human problem solving. J. exp. Psychol., 1959, 58, 52-55.

Ortar, P.R. Improving test validity by coaching. Educ. Res., 1960, 2, 137-142.

Osgood, C.E. Method and theory in Experimental Psychology. New York: Oxford Univer. Press, 1953.

Osgood, C.E. The similarity paradox in human learning: a resolution. Psychol. Rev., 1949, 56, 227-301.

Otis, A.S. Otis Quick Scoring Mental Ability Tests: Manual of Directions for Beta Test. New York: Harcourt Brace & Co., 1939.

Peel, E.A. Practice effects between three consecutive tests of intelligence. Brit. J. educ. Psychol., 1952, 22, 196-199.

Piaget, J. The psychology of intelligence. Trans. by M. Piercey & D. Berlyne. London: Routledge & Kegan Paul, 1947.

References (Cont'd)

Piaget, J. The construction of reality in the child (1937). Trans. by M. Cook. New York: Basic Books, 1954.

Piaget, J. The origin of intelligence in the child (1936). Trans. by M. Cook. New York: Int. Univer. Press, 1952.

Piaget, J. The language and thought of the child (1923). Trans. by M. Worden. New York: Harcourt, Brace, World, 1926.

Preston, M.G. Concerning the determination of trait variability. Psychometrica, 1940, 5, 275-281.

Raven, J.C. Guide to using the Progressive Matrices. London: H.K. Lewis & Co., Ltd., 1956.

Ryans, J. An experimental study of the transfer of training with special attention to the relation of intelligence to test performance. J. educ. Psychol., 1936, 27, 482-500.

Siipola, E.M., and Israel, H.E. Habit interference as dependent upon stage of training. Amer. J. Psychol., 1933, 45, 205-227.

Spearman, C. "General intelligence" objectively determined and measured. Amer. J. Psychol., 1904, 15, 201-293.

Spearman, C. The abilities of man. New York: The MacMillan Co., 1927.

Spielberger, C.D. Evidence of a practice effect on the Miller Analogies test. J. appl. Psychol., 1959, 43, 259-263.

Spitz, R.A. Hospitalism: an enquiry into the genesis of psychiatric conditions in early childhood. Psychoanal. stud. Child, 1945, 2, 313-342.

Stake, R.E. Learning Parameters, Aptitudes and Achievements. Princeton, N.J. Educational Testing Services, Technical Report, 1958.

References (Cont'd)

Stephens, J.M. In Grose, R.F., and Birney, R.C., (Eds.) Transfer of Learning. New York: D. Van Nostrand Co., Ltd., 1963.

Suchman, J.R. Inquiry training and science education. In H. Rueblis (Ed.) Laboratories in the classroom. New York: Science Materials Center, 1960.

Sullivan, A.M. Measurement of intelligence in different environments. Bull. Maritime Psychol. Ass., 1957, 6, 18-23.

Sullivan, A.M., and Schuurman, H. The Measurement of intelligence in Newfoundland. Unpublished manuscript distributed by the Nfld. Dept. of Education. 1961.

Thompson, W.R., & Heron, W. The effects of restricting early experience on the problem solving capacity of dogs. Canad. J. Psychol., 1954, 8, 17-31.

Thorndike, E.L. Practice effects on intelligence tests. J. exp. Psychol., 1922, 5, 101-107.

Thorndike, E.L. Mental Discipline in High School studies. J. educ. Psychol., 1924, 15, 1-22, 83-88.

Thurstone, L.L. Primary Mental Abilities. Chicago: Univer. of Chicago Press, 1938.

Tilton, J.W. The intercorrelations between measures of school learning. J. Psychol., 1953, 35, 167-179.

Townsend, E.A., & Burke, P.J. Learning for Teachers. New York: The Macmillan Co., 1962.

References (Cont'd)

Vernon, P.E. The Structure of Human Abilities. London: Methuen, 1950.

Vernon, P.E. Symposium on the effects of coaching and practice in intelligence tests: V. Conclusions. Brit. J. educ. Psychol., 1954, 24, 57-63.

Ward, L.B. Reminiscence and rote learning. Psychol. Monogr., 1937, 49, No. 220.

Wesman, A.T. A study of the transfer of training from High School subjects to intelligence. J. educ. Psychol., 1945, 39, 112-122.

Westley, G. In Buros (Ed.) The Fourth Mental Measurements Yearbook. Highland Park, N.J.: The Gryphon Press, 1953.

Wiseman, S., & Wrigley, J. The comparative effects of coaching and practice on the results of verbal intelligence tests. Brit. J. Psychol., 1953, 44, 83-94.

Woodrow, H. The effect of type of training upon transference. J. educ. Psychol., 1927, 18, 179-186.

Woodrow, H. The relation between abilities and improvement with practice. J. educ. Psychol., 1938, 29, 215-230.

Woodrow, H. Factors in improvement with practice. J. Psychol., 1939, 7, 55-70.

Woodworth, R.S., & Scholshberg, H. Experimental Psychology. New York: Henry Holt and Co., 1958.

Young, R.K., & Underwood, B.J. Transfer in Verbal Materials with dissimilar stimuli and response stimuli varied. J. exp. Psychol., 1954, 47, 153-159.

References (Cont'd)

Yum, K.S. An experimental test of the law of assimilation. J. exp. Psychol., 1931, 14, 68-82.

Appendix "A"

1. Instructions for Number Series practice.
2. Number Series practice 1 (for Number Series Test).
3. Number Series practice 2 (for Letter Series Test).
4. Instructions for the Letter Series Test (Revised).
5. Number Series Test.
6. Letter Series Test.
7. Letter Series Test (Revised).
8. Instructions for the Verbal Analogies practice.
9. Verbal Analogies practice.
10. Non-Verbal Analogies practice.
11. Instructions for the Verbal Analogies Test.
12. Verbal Analogies Test (30 item).
13. Verbal Analogies Test (40 item).
14. Non-Verbal Analogies Test.

Instruction for Number Series Practice

The sheet which you have contains 25 (or 24) problems. Look at problem Number 1. The numbers are arranged in a certain order, The order is the same that we use in counting. The next number in the Series is 7. Put the number 7 in the blank space on the right. (Problems 2, 3 and 4, are explained in a similar manner). That is what you have to do for each problem. The numbers are in a certain order. See what the order is and then figure out the one that comes next, on the right. Put the answer to each problem in the blank space on the right. Are there any questions? You will have plenty of time so there is no need to hurry. These problems are not difficult but try to pay attention to each one. Do not make careless mistakes. Try to get the correct answer to each problem. You may find that this will help you in another test you will be given later.

N - P

Name _____

1) 1 2 3 4 5 6 _____

2) 2 4 6 8 10 12 _____

3) 13 11 9 7 5 3 _____

4) 23 22 21 20 19 _____

5) 3 6 9 12 15 _____

6) 32 28 24 20 16 12 _____

7) 5 10 15 20 25 _____

8) 1/2 1/3 1/4 1/5 1/6 1/7 _____

9) 1/2 1/4 1/6 1/8 1/10 1/12 _____

10) 1/2 2/3 3/4 4/5 5/6 6/7 _____

11) 1/3 5/7 9/11 13/15 _____

12) 2 1/2 3 1/3 4 1/4 5 1/5 _____

13) 4 1/2 6 1/3 8 1/4 10 1/5 _____

14) 1/2 12 1/3 13 1/4 14 1/5 15 1/6 _____

15) 1 2 2 1 2 3 3 2 3 4 4 3 _____

16) 2 4 6 6 4 2 8 10 12 12 10 _____

17) 1 2 4 8 16

18) 81 27 9 3 _____

19) o o 1 o o 2 o o 3 o o 4 o o 5 _____

20) 0 1 0 0 1 0 0 0 1 0 0 0 0 _____

21) 0 2 0 4 0 6 0 8 0 10 0 12 0 _____

22) 0 0 0 0 0 5 0 0 0 0 4 0 0 0 3 0 0 2 0 _____

23) 1 2 123 3 4 345 5 6 567 _____

24) 3 7 33 37 73 77 333 337 373 _____

25) 3 5 4 6 8 7 9 11 10 12 14 13 _____

N - P (2)

NAME _____

1) 1 2 3 4 5 6 _____

2) 10 9 8 7 6 5 _____

3) 23 24 25 26 27 28 _____

4) 4 5 1 2 3 4 5 1 2 3 4 5 1 _____

5) 1 3 5 7 9 11 13 _____

6) 1 2 4 5 7 8 10 11 13 14 16 _____

7) 7 8 9 11 12 13 15 17 17 19 _____

8) 0 1 3 6 10 15 21 _____

9) 1 2 2 3 3 3 4 4 4 4 5 5 5 5 _____

10) 1 2 2 3 4 4 5 6 6 7 8 8 9 10 10 11 _____

11) 1 1 2 2 3 4 4 5 5 6 7 7 8 8 9 10 10 _____

12) 1 2 1 3 4 3 5 6 5 7 8 7 9 10 _____

13) 1 100 2 100 3 100 4 100 _____

14) 1 2 100 3 4 100 5 6 100 7 8 100 _____

15) 1 2 100 1 2 101 1 2 102 1 2 103 1 2 _____

16) 1 100 1 1 101 1 1 102 1 1 103 1 1 _____

17) 0 100 1 101 2 102 3 103 4 104 _____

18) 1 20 2 21 3 22 4 23 5 24 _____

19) 1 20 2 19 3 18 4 17 5 16 6 _____

20) 1 2 100 3 4 101 5 6 102 7 8 103 _____

21) 1 3 8 2 1 3 8 2 1 3 8 2 1 3 8 2 1 3 _____

22) 20 1 2 19 2 3 18 3 4 17 4 5 16 5 6 15 _____

23) 1 100 1 200 2 100 2 200 3 100 3 200 _____

24) 1 2 1 2 20 21 3 4 3 4 20 21 5 6 5 6 20 _____

Instructions for the Letter Series Test (Revised)

This test contains 40 problems. The problems are all of the same type. Look at the first example (A). The letters are arranged in a certain order. The order is the same as we use when saying the alphabet. The next letter would be - R. Put the letter R in the blank space on the right.

(Examples B and C are explained).

That is what you have to do for each problem. The letters are in a certain order. See what the order is and then figure out the letter that comes next on the right. Put the answer to each problem in the blank space on the right. Are there any questions?

You will have 10 minutes. See how many problems you can answer correctly. Go ahead.

H T

NAME: _____

1) 11 22 33 44 _____

2) 101 202 303 404 _____

3) 3 3 7 7 11 11 _____

4) 5 10 15 20 25 _____

5) 1 7 2 7 _____

6) 650 550 450 350 _____

7) 9 8 7 6 _____

8) 1 10 100 1000 _____

9) 1111 1112 1122 1222 _____

10) 8 13 11 16 14 19 17 _____

11) 3 7 8 12 13 17 _____

12) 22d 18d 14d 10d _____

13) 2 2/3, 3 3/4, 4 4/5, 5 5/6 _____

14) 12 9 13 10 14 11 _____

15) 3b 6b 9b 12b _____

16) 7 13 9 15 11 17 13 _____

17) 18 17 15 11 10 8 4 _____

18) 1 4 9 16 25 _____

19) 12 48 9 36 6 24 _____

20) 5 12 9 16 13 20 _____

DO NOT WRITE BELOW THIS LINE

A _____ I _____ C _____ C/E _____

N - T

21) 2 2 5 4 4 10 6 6 _____

22) 16 21 23 24 29 31 32 _____

23) 12 9 13 10 14 11 _____

24) 16 28 8 14 4 7 _____

25) 2 2 3 3 5 5 8 8 _____

26) 135 45 180 60 240 80 _____

27) 0 3 8 15 24 35 _____

28) 57 53 48 53 49 44 49 45 _____

29) 114 57 54 27 24 12 _____

30) 52 49 45 60 57 53 68 65 _____

31) 42 21 22 11 12 6 _____

32) 25 25 22 23 19 21 _____

33) 52 49 45 60 57 53 68 65 _____

34) 58 78 60 75 62 72 64 _____

35) 12 30 42 10 25 35 8 20 _____

36) 5 17 6 17 8 18 11 20 _____

37) 5 5 8 7 11 9 14 _____

38) 54 81 18 27 6 9 _____

39) 62 37 52 47 40 59 26 73 _____

40) 40 39 41 37 45 29 _____

L.

NAME: _____

1. J K L M N O P Q	_____
2. I H G F E D C	_____
3. P Q Q R R R S S S S	_____
4. B C C D E E F G	_____
5. C Z C C Y C C X C C	_____
6. B C D B C D E F G E	_____
7. H I I J K K L M M	_____
8. D E E F F F G G G	_____
9. G H I G H I J K L J	_____
10. B W C X B W C X B	_____
11. R S T C D E U V W C D	_____
12. X Y Z A B C D E	_____
13. W X Y W X Z W X A W X	_____
14. W X X Y Z Z A B B C D	_____
15. R S R T U T V W V X Y	_____
16. O X O Y P X P Y Q X Q Y	_____
17. S T U S T V S T W S T X	_____
18. M V M W N V N W O V O W	_____
19. R R S S T U U V V W X X Y	_____
20. D E B F G B H I B J K B L	_____

DO NOT WRITE BELOW THIS LINE

A_____ I_____ C_____ C/E_____

L.

21. S T S U V W X W Y Z _____

22. C Z C D Y D E X E F W F G _____

23. A B C A B D A B E A B F _____

24. R A T R B T R C T R _____

25. A T U B U V C V W D _____

26. R S T D E F Q R S G H I P _____

27. G H J K M N P Q S T V W _____

28. D X E W F V G U H T I S _____

29. H I J G H I J F G H I J _____

30. W X Y W X Z W X A W X B _____

31. H Z G H Z F G H Z E F G H Z _____

32. B D G K P V _____

33. A B C A A B C B A B C C A _____

34. E F E F C D G H G H C D _____

35. D P O N M E F L K J G H I _____

36. A Y B X C W _____

37. Z A C F J N Q S _____

38. R R S S T U U V V W X X Y _____

39. X D C B D C Y A Z Y A Z Z X W _____

40. A Z A A Y A A X A A W A A _____

L T

Name: _____

A.	J	K	L	M	N	O	P	Q						
B.	I	H	G	F	E	D	C							
C.	P	Q	Q	R	R	R	S	S	S					
1.	X	Y	Z	A	B	C	D	E						
2.	B	C	C	D	E	E	F	G						
3.	C	Z	C	C	Y	C	C	X	C	C				
4.	B	C	D	B	C	D	E	F	G	E				
5.	H	I	I	J	K	K	L	M						
6.	D	E	B	F	G	B	H	I	B	J	K	B	L	M
7.	D	E	E	F	F	F	G	G	G					
8.	G	H	I	G	H	I	J	K	L	J				
9.	B	W	C	X	B	W	C	X	B					
10.	R	S	T	C	D	E	U	V	W	C	D			
11.	W	X	Y	W	X	Z	W	X	A	W	X			
12.	W	X	X	Y	Z	Z	A	B	B	C	D			
13.	R	S	R	T	U	T	V	W	V	X	Y			
14.	O	X	O	Y	P	X	P	Y	Q	X	Q	Y		
15.	S	T	U	S	T	V	S	T	W	S	T	X		
16.	M	V	M	W	N	V	N	W	O	V	O	W		
17.	R	R	S	S	T	U	U	V	V	W	X	X	Y	
18.	V	X	Z	B	D	F	H							

19. S T S U V U W X W Y Z _____
20. C Z C D Y D E X E F W F G _____
21. A B C A B D A B E A B F _____
22. R A T R B T R C T R _____
23. A T U B U V C V W D _____
24. R S T D E F Q R S G H I P _____
25. G H J K M N P Q S T V W _____
26. D X E W F V G U H T I S _____
27. H I J G H I J F G H I J _____
28. A M N C N O E O P G P Q _____
29. W X Y W X Z W X A W X B _____
30. A C E H K O _____
31. H Z G H Z F G H Z E F G H Z _____
32. A B D G K P _____
33. A B C A A B C B A B C _____
34. E F E F C D G H G H C D _____
35. A Y B X C W _____
36. Z A C F J N Q _____
37. Z Y X W V U Y X W V U X W V U _____
38. A Z A A Y A A X A A W A A _____
39. D P O N M E F L K J G H I I _____
40. X D C B D C Y A Z Y A Z Z X W _____

Instructions for Verbal Analogies Practice

"This test contains 24 problems. Look at problem number 1. The first two words - finger and hand - are related in a certain way. Finger is a part of hand. Now, what we have to do is to find the word that is related to toe in the same way. There are five words below - which one is correct?"

Allow verbal responses.

"That's right - foot - now underline foot and put the number 2 in the blank space on the right."

Explain examples 2 and 3.

"That is all you have to do. Figure out the way the first two words are related and then find the word that is related to the third word in the same way. These are easy but work carefully because if you don't you may make silly mistakes and if you pay attention to this you may find it will help you in a test you will get later."

A P

1. Finger is to hand as toe is to _____
(1) apple (2) foot (3) arm (4) book (5) sock

2. Pencil is to paper as chalk is to _____
(1) orange (2) white (3) eraser (4) ink
(5) blackboard

3. Wrist is to arm as ankle is to _____
(1) head (2) foot (3) chair (4) leg (5) arm

4. Peel is to banana as shell is to _____
(1) skin (2) water (3) egg (4) juice (5) ripe

5. White is to chalk as _____ is to sky
(1) orange (2) green (3) cloudy (4) up (5) blue

6. Crying : sad as laughing : _____
(1) weep (2) happy (3) smile (4) like (5) hate

7. Wet : ocean as _____ : desert
(1) sand (2) tree (3) dry (4) camel (5) flower

8. Window : glass as door : _____
(1) wood (2) open (3) key (4) window (5) wall

9. Boy : man as girl : _____
(1) chicken (2) dress (3) woman (4) mother (5) wife

10. Black : white as _____ : light
(1) day (2) night (3) candle (4) dark (5) sun

11. Monday : Tuesday as Friday : _____
(1) Wednesday (2) Thursday (3) March (4) Saturday
(5) Sunday

12. Seed : plant as egg : _____
(1) chicken (2) dog (3) tree (4) leaf (5) sunshine

13. Inch : foot as ounce : _____
(1) pound (2) dollar (3) weight (4) scale (5) ton

14. Cent : nickle as nickle : _____
(1) dime (2) dollar (3) bank (4) candy (5) quarter

15. House : hotel as _____ : bus
(1) fare (2) engine (3) car (4) trailer (5) home

16. Watch : clock as _____ : trunk
(1) attic (2) tree (3) elephant (4) drawer
(5) suitcase

17. Dig : spade as cut : _____
(1) finger (2) knife (3) sharp (4) spade (5) blood

18. Kick : foot as _____ : hand
(1) ring (2) slap (3) jump (4) count (5) angle

19. Chair : sit as bed : _____
(1) night (2) pillow (3) lie (4) legs (5) sheet

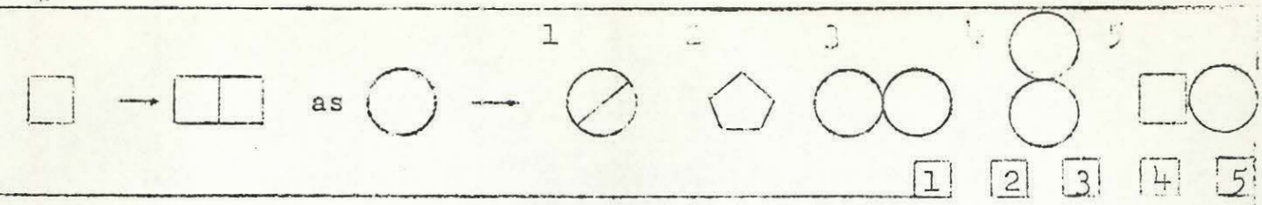
20. Car : drive as _____ : fly
(1) plane (2) bird (3) sky (4) airport (5) passenger

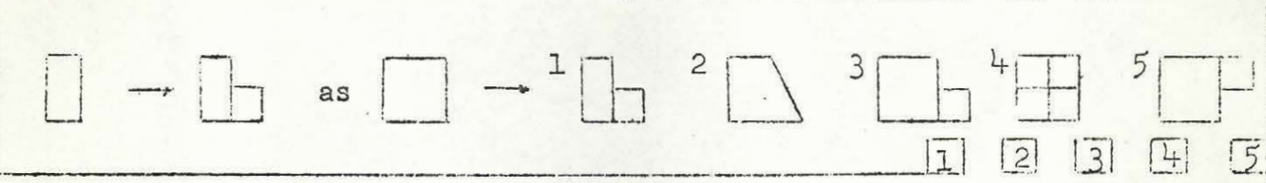
21. Dog : animal as robin : _____
(1) fly (2) nest (3) spring (4) bird (5) wings

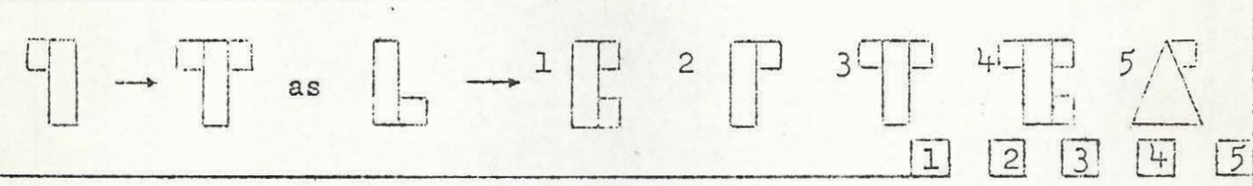
22. Coin : buy as _____ : mail
(1) mail (2) letter (3) stamp (4) envelope
(5) address

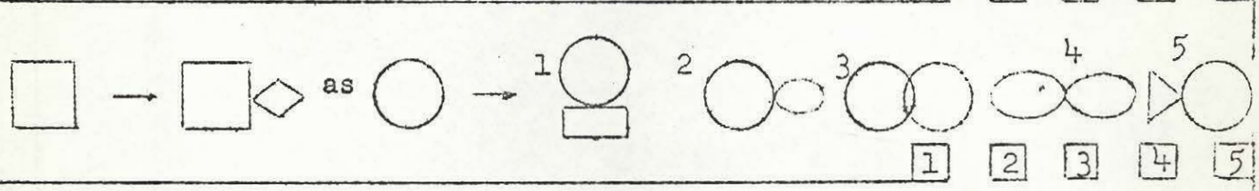
23. Fir : tree as tulip : _____
(1) spring (2) daisy (3) bulb (4) flower (5) red

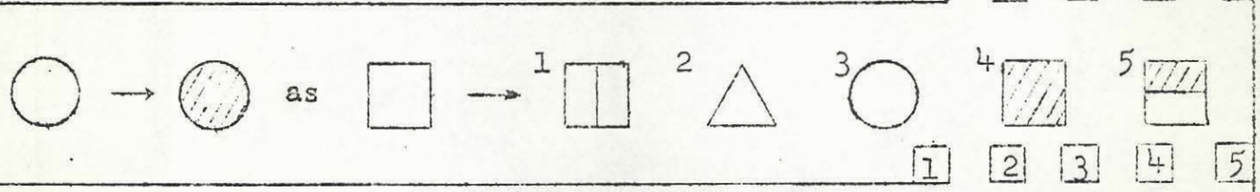
24. Love : peace as hate : _____
(1) war (2) anger (3) danger (4) ceasefire
(5) army

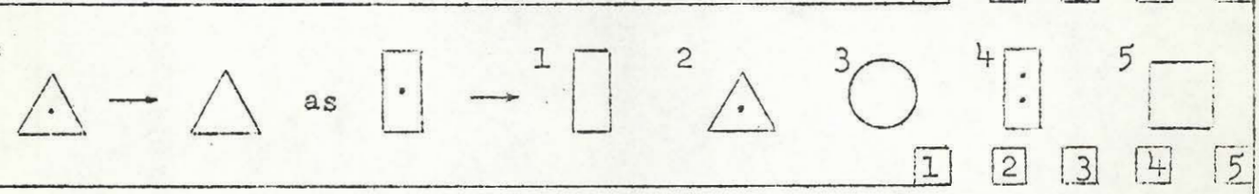
1) 

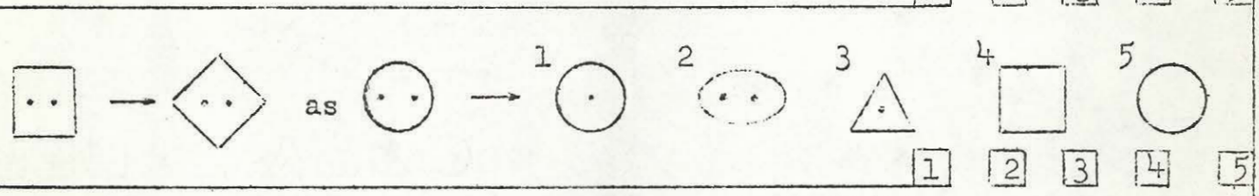
2) 

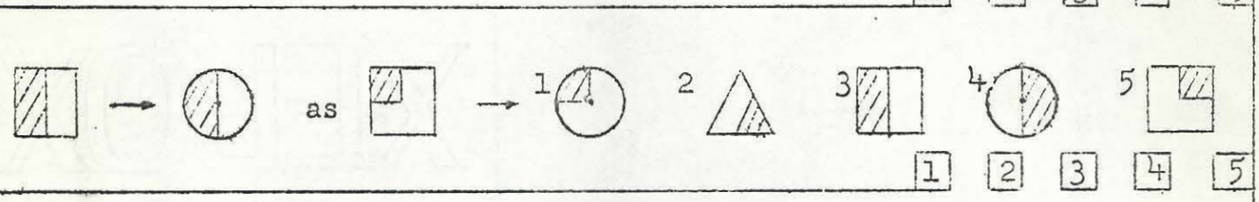
3) 

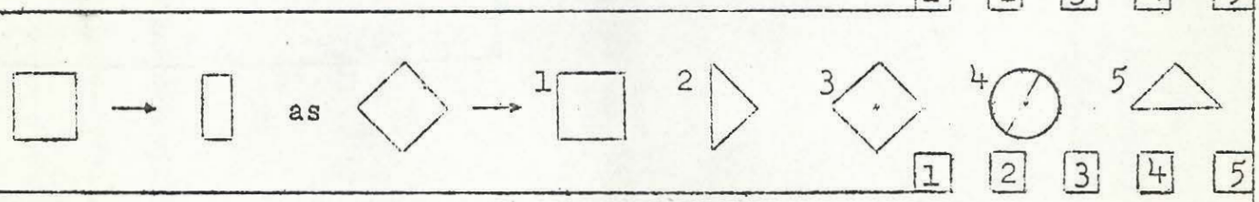
4) 

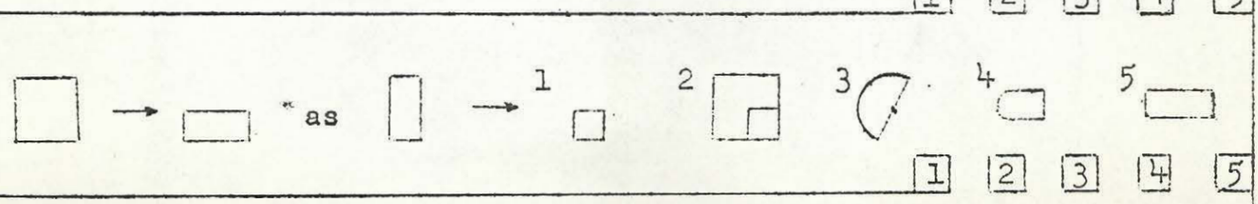
5) 

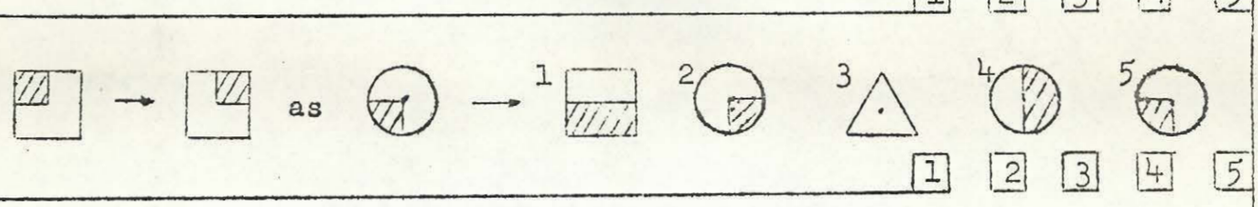
6) 

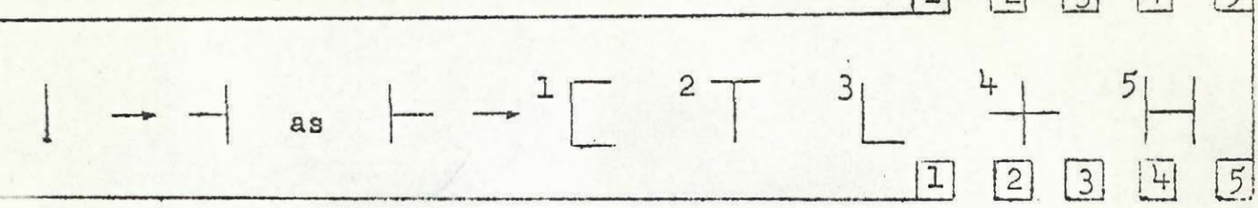
7) 

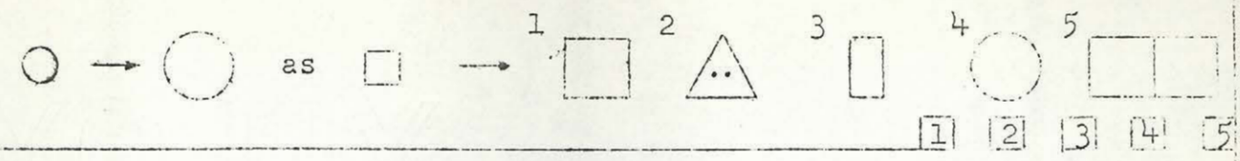
8) 

9) 

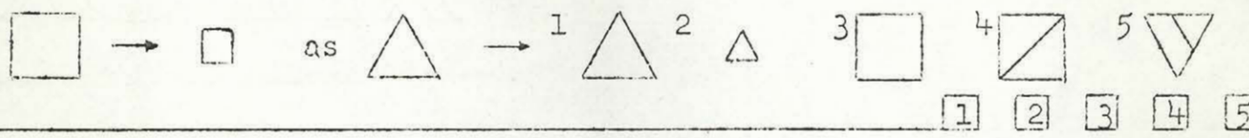
10) 

11) 

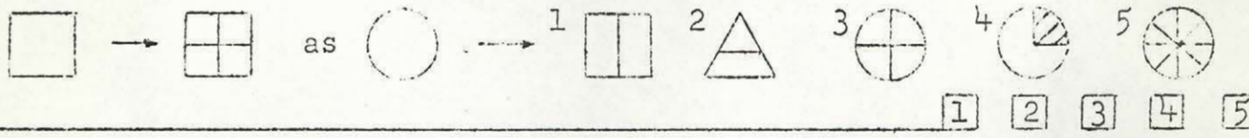
12) 

13) 

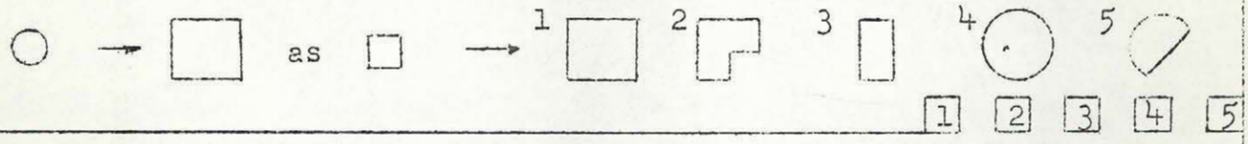
1 2 3 4 5

14) 

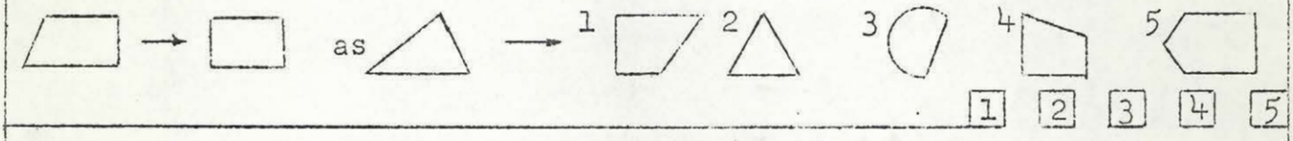
1 2 3 4 5

15) 

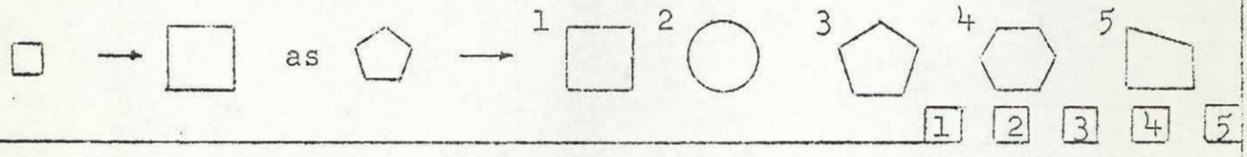
1 2 3 4 5

16) 

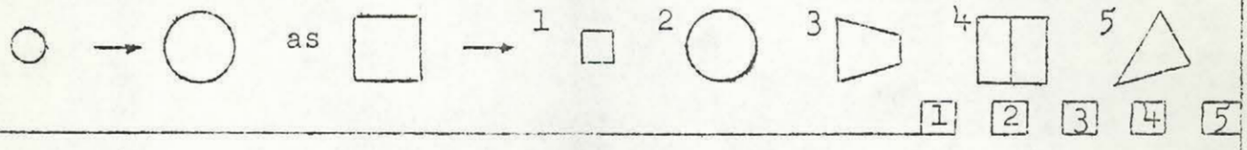
1 2 3 4 5

17) 

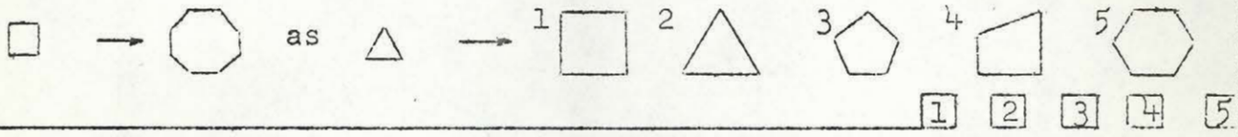
1 2 3 4 5

18) 

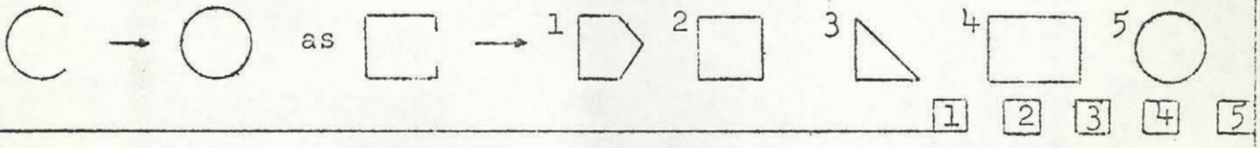
1 2 3 4 5

19) 

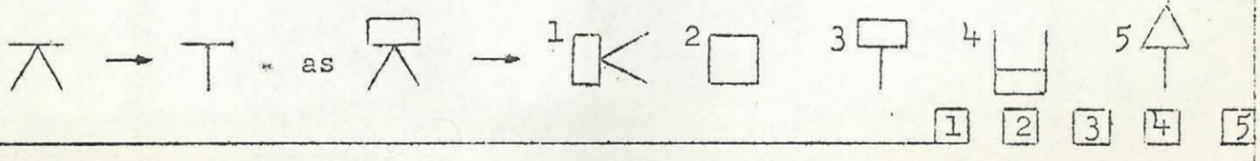
1 2 3 4 5

20) 

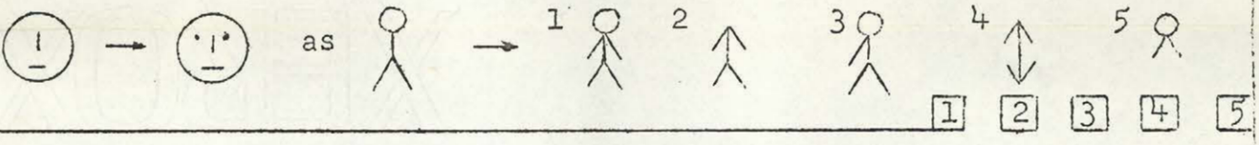
1 2 3 4 5

21) 

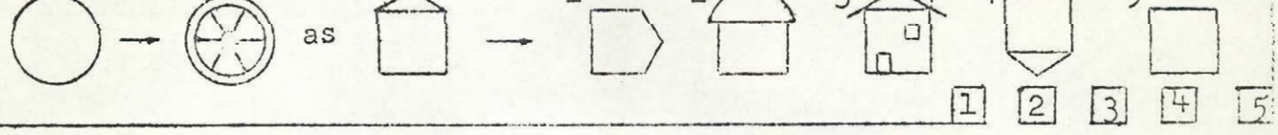
1 2 3 4 5

22) 

1 2 3 4 5

23) 

1 2 3 4 5

24) 

1 2 3 4 5

Instructions for Verbal Analogies Test

Analogies tests are placed on the desks upside down.

"This test contains 40 problems. Each problem has two words which are related to each other in some way. You have to find the word which is related to the third word in the same way.

For example: (Write on the blackboard)

white (is to : snow as black (is to : _____

You have to select your answer from five alternatives. These are (Read out) sun, coal, paper, water, apple. The correct answer is of course (Pause for verbal responses) coal because that is related to black in the same way that white is related to snow. Now turn over your papers and look at the first problem. Light is to day as dark is to what? Light and dark are related in a certain way - it is light during the day. What word is related to dark in the same way?..... That's right - night. Now underline night and put an X in the box which has the number of the correct answer - box number one."

"That is all you have to do for each problem. Figure out the way in which the first two words are related and then find the one which is related to the third one in the same way. Remember to underline the answer and put an X in the box with the correct number. Any questions? You have <u>eight</u> minutes. Go ahead.

A T

1. Light is to day as dark is to _____ _____
(1) night (2) moon (3) cave (4) black (5) sleep

2. Boy is to man as _____ is to sheep _____
(1) wool (2) lamb (3) goat (4) shepherd (5) dog

3. Vase is to flowers as _____ is to milk _____
(1) cow (2) bottle (3) white (4) drink (5) cream

4. Coal is to engine as _____ is to car _____
(1) motorcycle (2) wheels (3) smoke (4) gasoline
(5) horn

5. Sculptor is to statue as author is to _____ _____
(1) book (2) man (3) name (4) bookcase (5) pen

6. Automobile : wagon as motorcycle : _____ _____
(1) walking (2) horse (3) buggy (4) train
(5) bicycle

7. King : kingdom as president : _____ _____
(1) vice president (2) senate (3) republic (4) queen
(5) democrat

8. Revolver : man as _____ : bee _____
(1) wings (2) honey (3) flying (4) wax (5) sting

9. Lamp : light as _____ : breeze _____
(1) fan (2) bright (3) sailboat (4) window
(5) cool

10. Wire : electricity as _____ : gas _____
(1) flame (2) spark (3) hot (4) pipe (5) stove

11. Peace : war as _____ : confusion _____
(1) explosion (2) order (3) armistice (4) riot
(5) police

12. Heat : flame as _____ : rose _____
(1) red (2) tree (3) scent (4) nose (5) thorn

13. Egg : bird as _____ : plant _____
(1) seed (2) shell (3) leaf (4) root (5) feathers

14. Water : steam as ice : _____ _____
(1) skate (2) cream (3) hard (4) water (5) cold

15. Apple : orange as pea : _____ _____
(1) grapefruit (2) banana (3) carrot (4) potato
(5) bean

16. Bush : tree as seal : _____ _____
(1) frog (2) snake (3) water (4) whale (5) cod

17. Hospital : sick as _____ : criminals _____
(1) doctor (2) asylum (3) judge (4) prison
(5) sentence

18. Circle : square as sphere : _____ _____
(1) circumference (2) cube (3) round (4) corners
(5) ball

19. Peninsula : land as _____ : ocean _____
(1) river (2) lake (3), cape (4) gulf (5) water

20. Ellipse : circle as _____ : square _____
(1) cube (2) curve (3) oval (4) circle
(5) diamond

21. Better : good as worse : _____ _____
(1) very good (2) medium (3) bad (4) much worse
(5) best

22. Violence : anger as _____ : love _____
(1) caressing (2) hate (3) temper (4) hope
(5) happiness

23. Large : object as loud : _____ _____
(1) soft (2) small (3) heavy (4) weight (5) sound

24. Wet : water as _____ : fog _____
(1) dry (2) damp (3) cold (4) rain (5) cloud

25. Grass : milk as _____ : bread _____
(1) salt (2) flower (3) yeast (4) dough (5) wheat

26. Education : ignorance as _____ : poverty _____
(1) laziness (2) school (3) wealth (4) charity
(5) teacher

27. Point : line as line : _____ _____
(1) surface (2) pencil (3) dot (4) curve (5) solid

28. Sanitation : disease as _____ : accident _____
(1) doctor (2) hospital (3) bandage (4) cleanliness
(5) care

29. Ordinary : exceptional as many : _____ _____
(1) all (2) none (3) few (4) common (5) more

30. Evolution : revolution as crawl : _____ _____
(1) baby (2) floor (3) stand (4) run
(5) hands and knees

A T

1. Light is to day as dark is to _____ 1 2 3 4 5

(1) night (2) moon (3) cave (4) black (5) sleep

2. Boy is to man as _____ is to sheep 1 2 3 4 5

(1) wool (2) lamb (3) goat (4) shepherd (5) dog

3. Vase is to flowers as _____ is to milk 1 2 3 4 5

(1) cow (2) bottle (3) white (4) drink (5) cream

4. Coal is to engine as _____ is to car 1 2 3 4 5

(1) motorcycle (2) wheels (3) smoke (4) gasoline

(5) horn

5. Sculptor is to statue as author is to _____ 1 2 3 4 5

(1) book (2) man (3) name (4) bookcase (5) pen

6. Automobile : wagon as motorcycle : _____ 1 2 3 4 5

(1) walking (2) horse (3) buggy (4) train

(5) bicycle

7. King : kingdom as president : _____ 1 2 3 4 5

(1) vice president (2) senate (3) republic (4) queen

(5) democrat

8. Revolver : man as _____ : bee 1 2 3 4 5

(1) wings (2) honey (3) flying (4) wax (5) sting

9. Lamp : light as _____ : breeze 1 2 3 4 5

(1) fan (2) bright (3) sailboat (4) window

(5) cool

10. Wire : electricity as _____ : gas 1 2 3 4 5

(1) flame (2) spark (3) hot (4) pipe (5) stove

11. Peace : war as _____ : confusion

(1) explosion (2) order (3) armistice (4) riot (5) police

12. Heat : flame as _____ : rose

(1) red (2) tree (3) scent (4) nose (5) thorn

13. Egg : bird as _____ : plant

(1) seed (2) shell (3) leaf (4) root (5) feathers

14. Water : steam as ice : _____

(1) skate (2) cream (3) hard (4) water (5) cold

15. Apple : orange as pea : _____

(1) grapefruit (2) banana (3) carrot (4) potato (5) bean.

16. Bush : tree as seal : _____

(1) frog (2) snake (3) water (4) whale (5) cod

17. Hospital : sick as _____ : criminals

(1) doctor (2) asylum (3) judge (4) prison (5) sentence

18. Circle : square as sphere : _____

(1) circumference (2) cube (3) round (4) corners (5) ball

19. Peninsula : land as _____ : ocean

(1) river (2) lake (3) cape (4) gulf (5) water

20. Ellipse : circle as _____ : square

(1) cube (2) curve (3) oval (4) circle (5) diamond

21. Better : good as worse : _____ 1 2 3 4 5

(1) very good (2) medium (3) bad (4) much worse

(5) best

22. Year : earth as _____ : moon 1 2 3 4 5

(1) month (2) spring (3) season (4) day

(5) decade

23. Large : object as loud : _____ 1 2 3 4 5

(1) soft (2) small (3) heavy (4) weight (5) sound

24. Wet : water as _____ : fog 1 2 3 4 5

(1) dry (2) damp (3) cold (4) rain (5) cloud

25. Grass : milk as _____ : bread 1 2 3 4 5

(1) salt (2) flower (3) yeast (4) dough (5) wheat

26. Education : ignorance as _____ : poverty 1 2 3 4 5

(1) laziness (2) school (3) wealth (4) charity

(5) teacher

27. Point : line as line : _____ 1 2 3 4 5

(1) surface (2) pencil (3) dot (4) curve (5) solid

28. Sanitation : disease as _____ : accident 1 2 3 4 5

(1) doctor (2) hospital (3) bandage (4) cleanliness

(5) care

29. Ordinary : exceptional as many : _____ 1 2 3 4 5

(1) all (2) none (3) few (4) common (5) more

30. Evolution : revolution as crawl : _____ 1 2 3 4 5

(1) baby (2) floor (3) stand (4) run

(5) hands and knees

31. U. S. A. : America as U. S. S. R. : _____ 1 2 3 4 5

(1) China (2) Berlin (3) Moscow (4) Russia
(5) France

32. Thermometer : temperature as Barometer : ____ 1 2 3 4 5

(1) weather (2) rain (3) pressure (4) snow (5) wind

33. Food : stomach as air : _____ 1 2 3 4 5

(1) lungs (2) brain (3) life (4) breathing
(5) heart

34. Quill: typewriter as _____ : electric light 1 2 3 4 5

(1) fire (2) dark (3) lamp (4) bulb (5) candle

35. Ottawa : Washington as Paris : _____ 1 2 3 4 5

(1) London (2) Rome (3) Amsterdam (4) Warsaw
(5) Osto

36. Spelling : dictionary as Geography : _____ 1 2 3 4 5

(1) map (2) compass (3) test (4) atlas (5) History

37. 4 : 13 as 8 : _____ 1 2 3 4 5

(1) 62 (2) 27 (3) 43 (4) 44 (5) 17

38. Telescope : microscope as planet : _____ 1 2 3 4 5

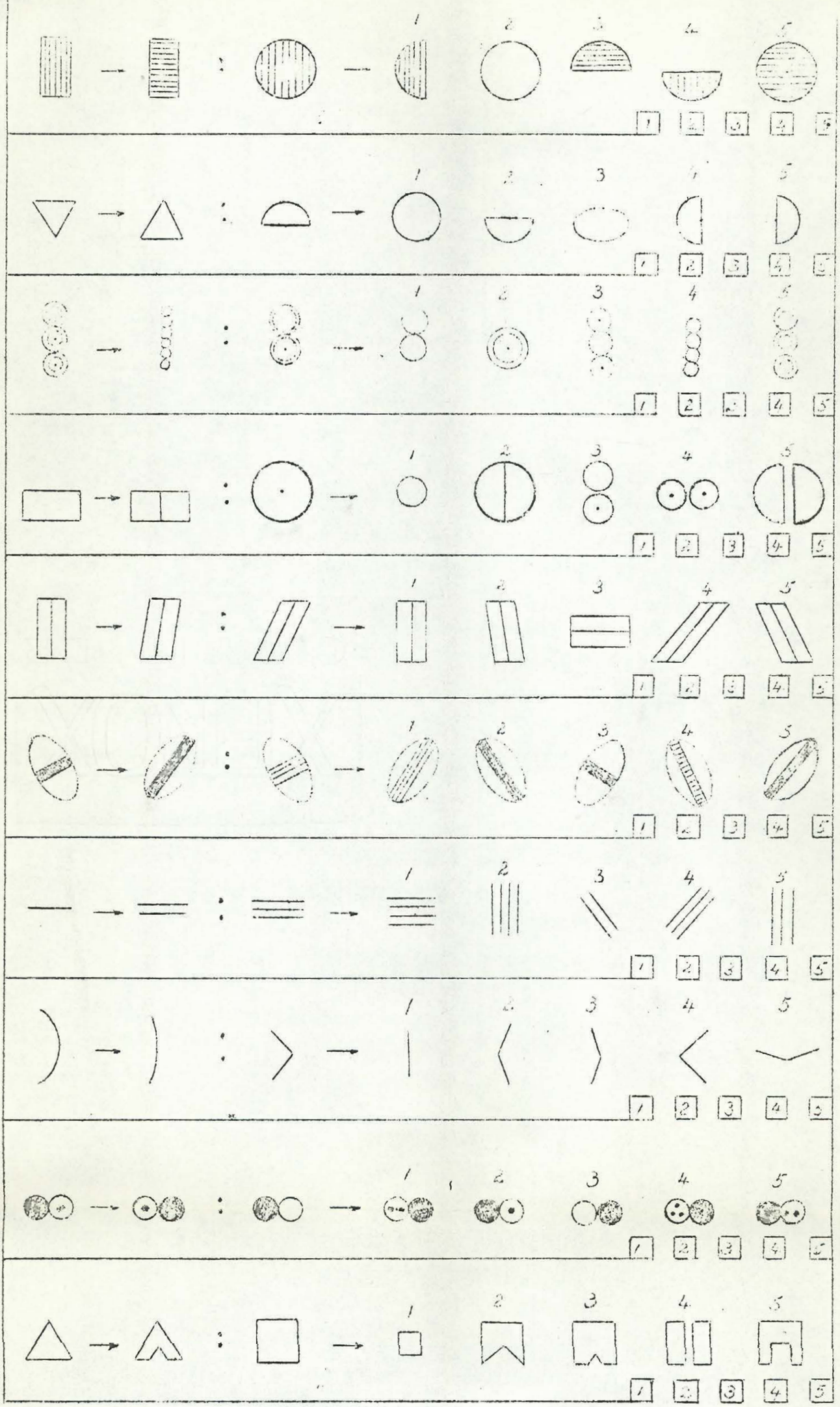
(1) star (2) atom (3) sun (4) nucleus (5) earth

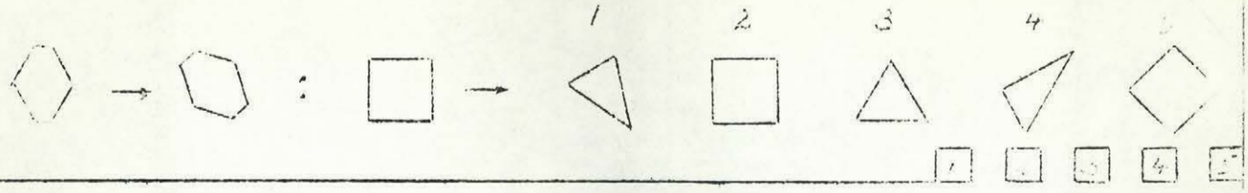
39. British Colombia : Canada as _____ : America 1 2 3 4 5

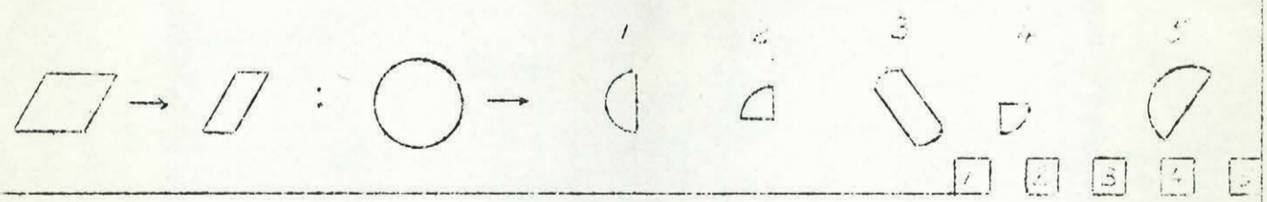
(1) San Francisco (2) Maine (3) California (4) Boston
(5) Texas

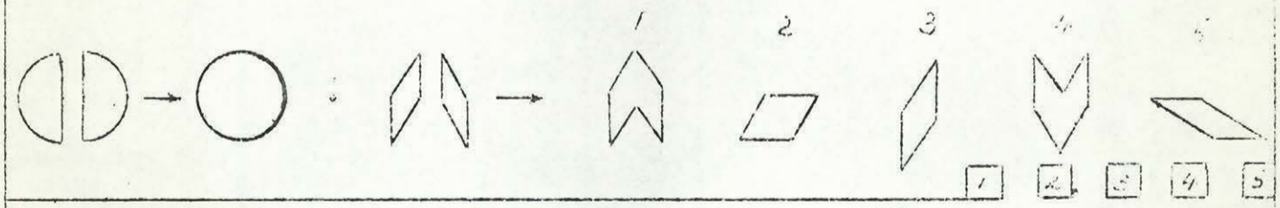
40. Compass : Colombus as _____ : bat 1 2 3 4 5

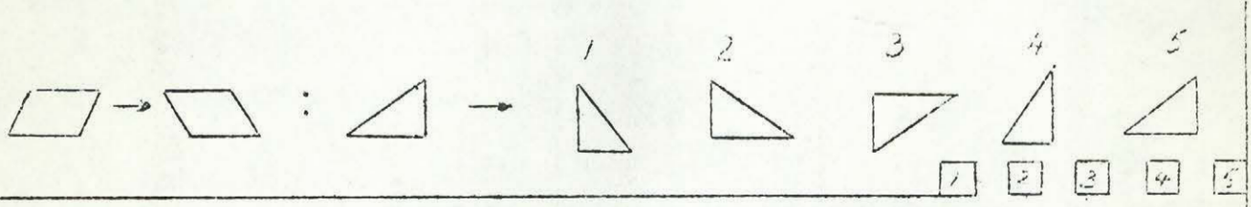
(1) wings (2) eyes (3) sound (4) flying (5) bird

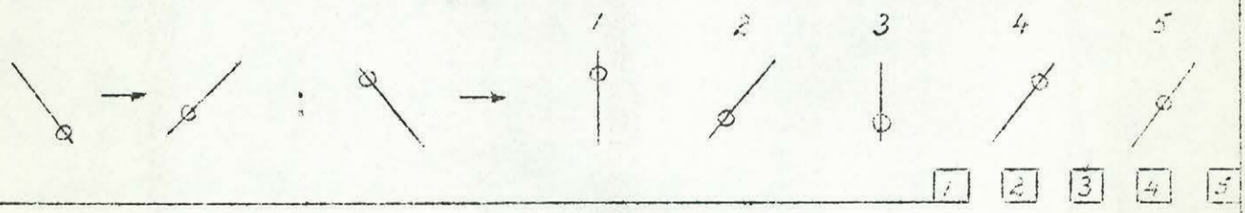

1
2
3
4
5
6
7
8
9
10

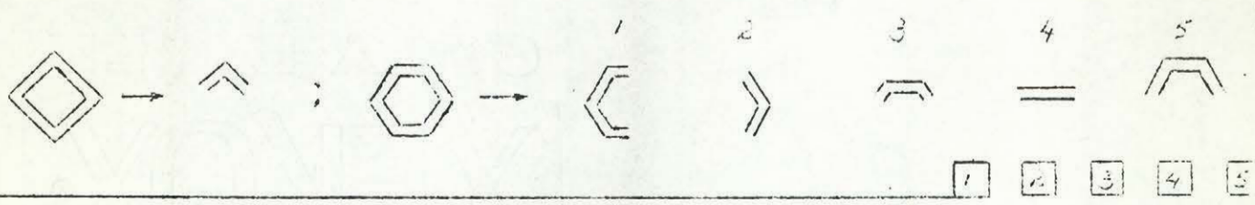
11 

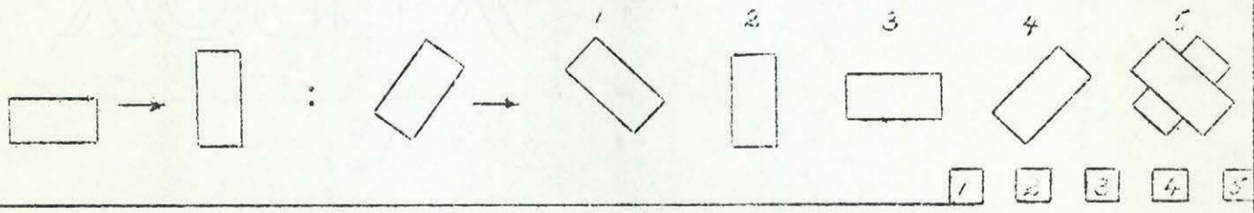
12 

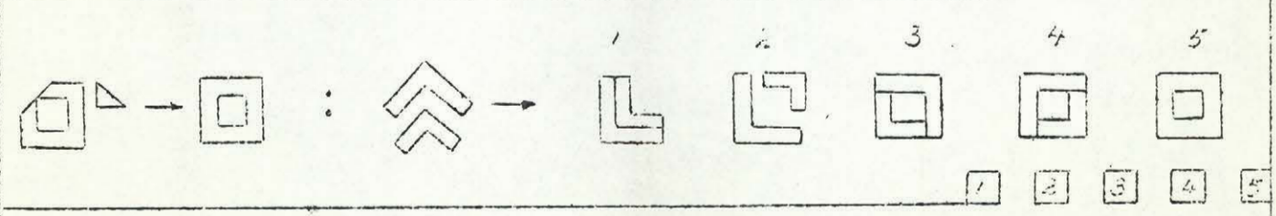
13 

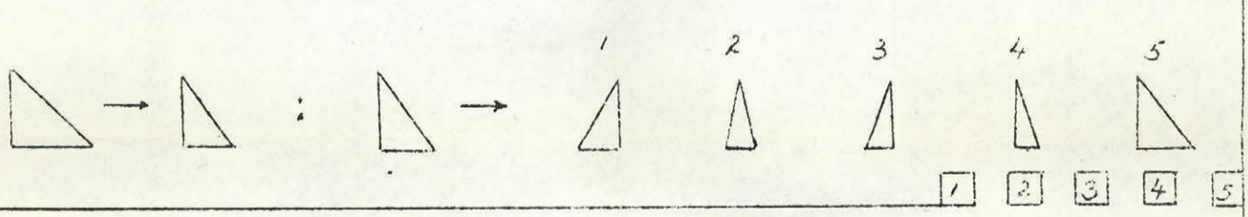
14 

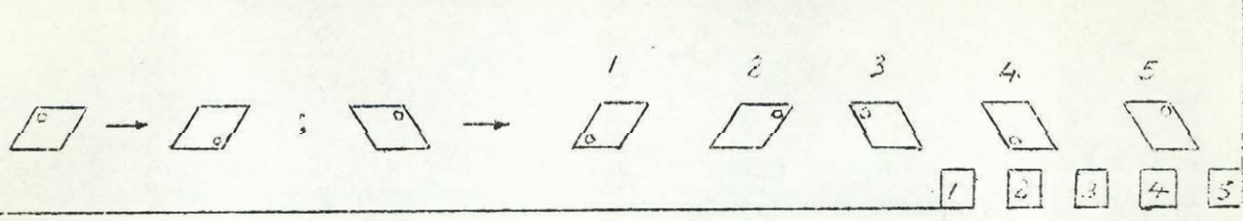
15 

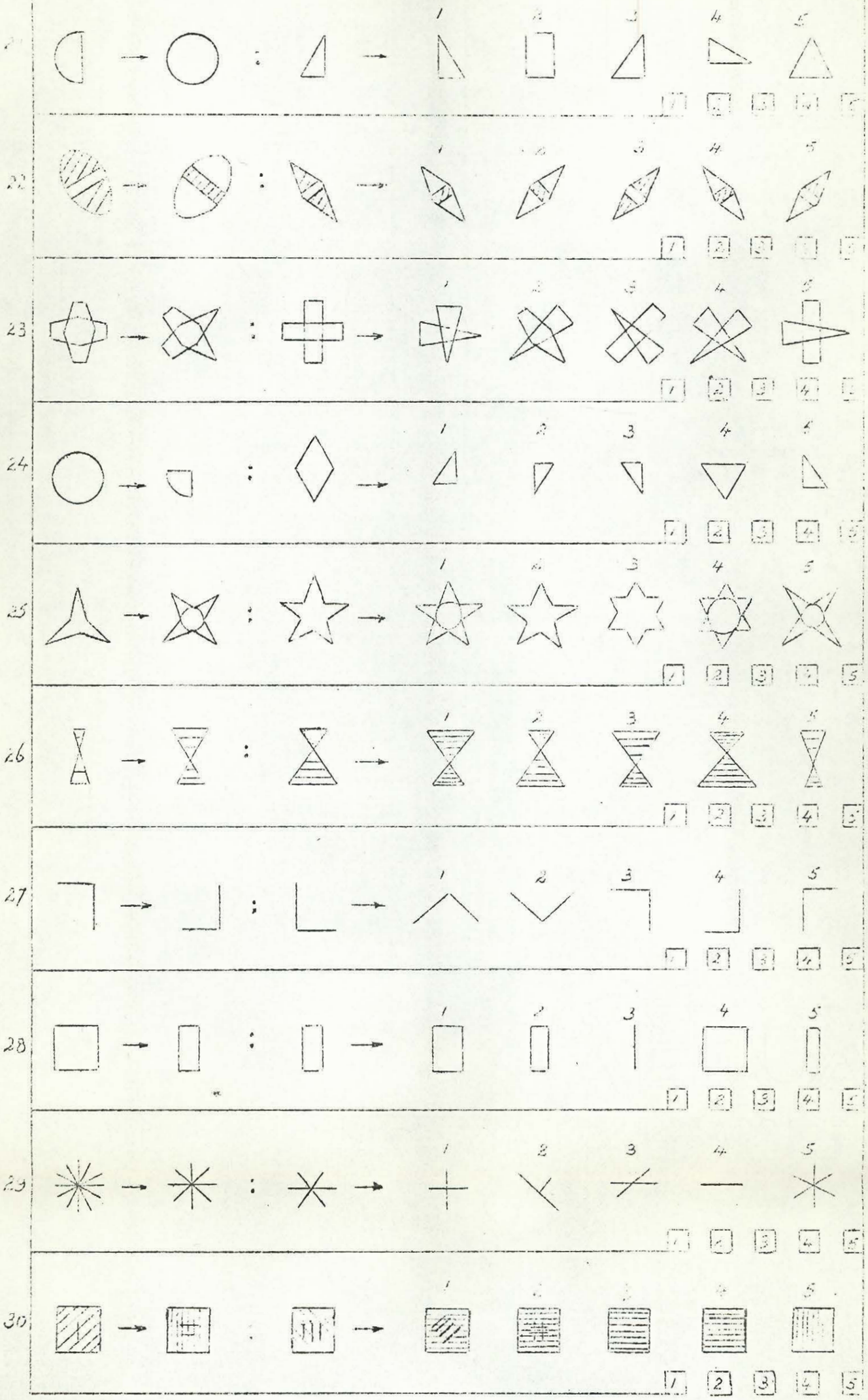
16 

17 

18 

19 

20 


22
23
24
25
26
27
28
29
30