Mental Set and Shift

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BY
ARTHUR T. JERSILD, PH.D.

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TABLE OF CONTENTS

Mental Set And Shift

CHAPTER I

Introduction

The fact of mental set is primary in all conscious activity. The same stimulus may evoke any one of a large number of responses depending upon the contextual setting in which it is placed. A series of two-place numbers is being called: to the pupil in an arithmetic class the numbers serve as stimuli for mental addition or multiplication; to the foot-ball player on the field the same numbers serve as signals calling into play certain preparatory muscular reactions; to the man in a trolley car the numbers designate names of streets. In each case the objective stimuli are the same, but the response patterns are widely different.

The significance of mental set as here presented is by no means a new observation in psychology. We stress it only to introduce the considerations which follow. For just as all activity is colored and influenced by the predominance of a mental set, so also it involves an element of constant adjustment, an element of shift. The old laws of span, duration, and fluctuation of attention bear witness to the fact of periodic change in the responses made to a homogeneous repertory of stimuli. The necessity for continued adjustment inheres also in the elements of a given task taken by itself.

Ordinarily one tends to overlook the fact of adjustment. Discrete elements within a single task become telescoped and fused through the automatizing influence of habit. Even the larger units in a person's activity take on the appearance of unified wholes. The fact of adjustment, evidenced by the slow and halting manner in which one goes about to coordinate the elements of a new habit, is gradually masked by practise. Change certain details of the task, combine old elements in a new way, and the smoothness of the operation is temporarily destroyed. The continuity of function is broken into discrete activities; the fact of shift effects is demonstrated; and the cost of shift is loss in efficiency.

Consequently, the more homogeneous and uniform the elements that comprise a given task, the less will be the demand for constant adjustment, the greater will be the potency of a given mental set, and the greater the efficiency of the performance. For this reason the problem of set and shift has been of special significance in the field of applied psychology. The trend in industry has been toward specialization. The mechanic of a generation ago who built a finished machine has been replaced by the worker who spends his time in the construction of a single rod or burr. By specialization of tasks the element of shift has been reduced to a minimum. The more simple the components of a mental set, according to the theory underlying this procedure, the more efficiently will the work proceed.

But the problem of set and shift has implications that bear directly also upon points that have been raised in systematic psychology. An old law of attention states that a person cannot attend to more than one thing at a time. To combine into one performance two or more distinct activities calls for continued shift from one mental set to another. Ordinarily it is supposed that shift of this kind entails an added expenditure of time and energy. It is the purpose of the present investigation to study the implications of this supposition and to analyze the factors involved in what may be called mental set and the shift from one set to another. A wide range of tests, calling for associative reactions, has been employed. All the tests are designed to give a measure of proficiency in simple tasks when taken singly and when combined with one or more other tasks into one composite shift performance. In each shift test the subject is required to alternate from an element of one type of test to an element of another type of test. The specific problems under investigation are as follows:

1. In a given array of combinations of task, does shift always involve a loss in efficiency? Is the loss more pronounced in some combinations than in others? What light is thrown upon the function of mental set and shift by such differences as appear?

2. With a given type of task, what is the effect of increasing the difficulty of the elements between which shift must be made? What is the effect of increasing the number of processes that constitute the complex shift performance?

3. What is the role of practise in determining the efficiency of a shift task? Does the loss entailed by shift tend to disappear with practise?

4. What general factors constitute the ability to shift? Is shift-ability related to general intelligence? Is it a special ability? Or can it be regarded as a function of the general type of ability that makes for proficiency in the separate activities that comprise the shift performance?

Historical Survey

Investigations relating to the general problem involved in mental set and shift fall under a variety of headings. They include studies of the distribution of attention, the faculty of attention, the power of distributing attention as related to general intelligence, perseveration, interference, and adaptability as affected by practise.

The work of Culler[1] is especially significant for the light which it throws upon the influence of practise in overcoming interference effects. Culler employed experiments in card-sorting, typewriting, and discrimination reactions. The subjects were required to practise a performance according to one procedure for a given number of trials and then were required to perform the same operation according to a changed procedure. Culler concludes from his work that

> "when two or more opposing associations, each of which excludes the other, are alternately practised with one, four, or eight repetitions of each association before the other is resumed, the opposing associations have an interference effect upon each other in all subjects. The interference effect grows less and less while the practise effect becomes greater. The interference effect is gradually overcome and both associations become automatic so that either of them can be called up without the appearance of the other. The curves of the alternating groups follow a straight but descending line and gradually approach the true practise curve."

Under the heading of Perseveration come studies made by Müller and Pilzecker, Foster, Wiersma, and Lankes. Of these the study made by Lankes[2] is most extensive and representative. He devised a number of tests to measure the hindrance effect of perseverative tendencies. Among these tests were the following:

Tapping.—The number of taps in a given interval of time

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[1] *Interference and Adaptability*, Archives of Psych., No. 24. 1912.
[2] *Perseveration*, Brit. Jour. of Psych., No. 7, 1915, pp. 387-419.

was here taken as the individual's score; a high tapping score was taken to indicate low perseverative tendency.

Free association responses to nonsense syllables.—Again the immediate score obtained was used; the speedier the associations, the lower the perseverative tendency.

Color discs.—The individual's ability to discriminate the component colors of rotating color discs was here measured; the greater the discriminatory ability, the greater the absence of perseverative tendency.

Cancellation, first of one set of letters, then of another.—The loss entailed in doing the second operation, expressed in terms of the ratio which the latter score bore to the former, was here used as the measure of perseveration, the supposition being that an individual of high perseverative tendency would be more handicapped in moving from one procedure to the next.

Drawings to be reproduced, in one case with single, and in another with double copy exposures.—The drawings were scored in each case and the single copy reproductions compared with those reproduced from the double copy exposures, the supposition being that the high perseverator would be more handicapped in the latter case; hence the measure used was the ratio which the score in the latter procedure bore to that obtained in the former.

Essays written on assigned themes, in one case with a four-minute, and in another with a forty-second writing period.—Here again the essays were scored, the relative merits of the forty-second production compared with the essay written in the four-minute period was taken as a measure of perseveration; the supposition was that the high perseverator would be at a greater advantage in the longer period.

Letter-writing, first in the forward, then in the reverse order.—The individual's score in the latter was compared with his score in the former test, and the ratio between the two scores obtained; the poorer the score in the second test, the higher would be the perseveration score.

Lankes also devised an interrogatory designed to detect perseverative tendencies on ideational, motor, and habit levels. He found a consistent positive correlation between the measure of perseveration as determined by the various tests, the correlations being small in each case. He concludes that "in spite of the lowness of all the single correlations they must be the result of a general factor influencing all the performances tested." This general, common factor, which he designates the Perseveration factor, cannot, he maintains, be

> "general ability, which will scarcely be supposed to influence, *e.g.*, tapping, or color discs, or the various functions tested by the interrogatory, and which in all other experiments (except only associative reactions) would needs be eliminated in the result, because equally entering into the numerator and denominator."

He concludes further that this perseveration factor is a "native quality of the nervous system, innately different with different individuals."

It will be observed that Lankes was mainly interested in the study of individual differences. He dismisses the question as to how closely an individual's ability to resist the hindrance effect of perseveration is bound up with his general ability by introducing the theory of a special Perseveration factor, innately different with different individuals. A similar quest for a special factor is also pursued by other investigators. Thus Wynn Jones,[3] in a study of perseveration, applied a series of tests based on the same general principle as those used by Lankes. He interprets his results as confirmatory of the theory of a special group factor. In a study entitled *Quickness and Intelligence,* Bernstein[4] makes use of tests of perseveration in connection with other estimates and tests. He concludes that there is no clear evidence for the existence of a separate "speed ability."

McQueen,[5] in a study of the distribution of attention, gives a summary of the previous work done on attention span, particularly as it relates to the study of the simultaneous performance of two separate tasks. From the results of his experiments, covering the activities of adding and tapping, card-sorting and counting by 3's, discrimination of the size of circles and dotting (an adaptation of McDougall's dotting test), he concludes that the supposed general power of "distribution of attention" does not exist. Says he, "The power of distribution seems to be specific in every case." He states also that persons of high intelligence, as determined by per-

[3] Report Brit. Assoc. for Adv. of Science, 1915, p. 698.
[4] Brit. Jour. Psych. Monog. Suppl. VII, 1924.
[5] Brit. Jour. Psych. Monog. Suppl. V, 1917.

sonal estimates, do not appear more capable of distributing the attention than those of less intelligence.

Somewhat at variance with McQueen's results are those obtained by Woodrow[6] in a study of the faculty of attention. In an experiment employing four situations, simple reactions to touch, to sound, to light, and choice reactions to the intensity of light, he measured the degree of attention of each of twelve subjects. The degree of attention was measured by the degree of prolongation in reaction time produced by changing the length of the "fore-period" from a uniform interval of two seconds to irregular intervals of different lengths. He concludes from his study that "every individual has a certain power or faculty of attention, in the sense that the degree of his attention is determined in part by general conditions which remain effective in spite of variation of the specific type of mental activity in question." He regards his findings as confirmatory of Spearman's theory of two factors. The individual's general capacity for attention, he suggests, might be identified with the factor called "general ability."

Hollingworth, in his study of the Influences of Alcohol[7] considers the general problem of competence and susceptibility. In this connection he points out a significant feature in Woodrow's data, namely, that it is not only true that individuals who are susceptible to disturbance in one situation are correspondingly so in others, but it is also true that "the susceptible individuals are those whose normal reactions are slow; that is, the susceptible are the incompetent." The far-reaching significance of this statement goes beyond the specific province of the present study. Yet it may prove a valuable asset in providing a clue to the analysis of mental set and shift as attempted in this investigation.

It will be seen that the studies reported above were mainly concerned with individual differences. It is not the purpose of the present study to make a special investigation of individual differences as they express themselves in ability to shift. A study of this kind would constitute an investigation in itself. But we report the findings and conclusions of these investigators to indicate the general line of attack made upon problems somewhat allied to the problem here studied, and to show how previous studies have disposed of the subject by

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[6] Jour. Exp. Psych., 1916, pp. 285-318.
[7] Jour. Abn. and Soc. Psych., 1924, p. 329 ff.

relating it to the individual rather than to the task, and by subsuming their findings under the theory of special factors.

The specific problem of mental set and shift was first raised by Hollingworth and Poffenberger in their book on Applied Psychology.[8] It is from these authors that the title of the present study is borrowed. In connection with the discussion on the topic, they express the principle that "in general it is found that shifting back and forth from one mental set, one attitude or task to another, is a relatively ineffective mode of work." The investigations reported above, so far as they have involved experiments analogous to the shift operation, bear out this general principle. It remains for the present study further to test the validity of this principle and to analyze the findings that appear. We shall be concerned with individual differences only in so far as they throw light upon the operation of the shift function.

[8] *Applied Psychology*, D. Appleton and Co., 1919, p. 222.

CHAPTER II

Mental Set and Shift as Related to the Type of Task

Our first concern will be to investigate the effect of shift when introduced into various combinations of tasks. The procedure used in the present experiment varies from that usually employed in studies of interference where an element of shift has been involved. Culler's subjects, for example, would sort a pack of cards, first according to one set of directions, then according to another; Lankes's subjects would cancel given letters throughout an entire cancellation blank and then, as a test of perseveration, would be required to cancel another letter or group of letters. The shift was from one completed task to another. In the present case all the experiments have been arranged to require shift, not between complete tasks, but from an element of one task to an element of another. To illustrate: In a certain calculation test one task was to add 6 to each of a column of two-place numbers; this constituted one of the separate tasks. Another task was to subtract 3 from each number. The shift test presented two columns of numbers, the subject was required to add 6 to the first number, subtract 3 from the second, add 6 to the third, then subtract 3, and so on through the two columns.

From the above illustration it can be seen that two significant scores could be obtained from each test: first, the score combining the records made in the two separate tasks; and second, the score obtained in the shift task. A third measure of shift effects can be derived from these two scores. It can be expressed in terms of the percentage of loss which the score in the shift task bears to the score in the separate tasks. In the present experiment most of the tests used were given according to the Amount Limit method, with time as the variable measure. Accordingly, where shift made for a loss in efficiency, more time would be required by the shift test than by the separate tasks, and the additional time requirement could be calculated as a percentage of the score in the separate tasks.

The materials used in this experiment include tests of calculation in five degrees of difficulty; controlled association; color naming and form naming, as separate tests and in combination; form naming and substitution; counting by 2's and 3's; calculation and controlled association; cancellation; and a test combining the four processes of color naming, form naming, calculation, and controlled association into one shift performance. The various tests will be described in connection with the discussion of the results. We shall first consider the calculation tests.

Calculation

In these experiments the materials consisted of the Woodworth and Wells blanks containing four columns of twenty-five two-place numbers. In all cases the single two-place number constituted the separate problem unit. The responses were given in writing. A description of the procedure follows:

1. Adding and Multiplying. In the first column, add the two digits that comprise the two-place number (*e.g.*, the first number is 64, the correct response to the problem 6 plus 4 is 10); in the second column multiply the two digits (the first number in the column is 72, the correct response is 14); in the third and fourth columns, add the two digits of the first number, multiply the two digits of the second number, then add, then multiply, and continue in this way through the third, and then through the fourth column, alternately adding and multiplying.

This test, as well as those which follow, was given under two conditions. One group of subjects was required to do the separate tasks first and then proceed with the shift columns; another group first completed the shift performance and then turned to the separate tasks.

Separate time records were taken for the first, second, and the third and fourth columns. The sum of the first two records gave the score for the separate tasks; the time record for the third and fourth columns gave the shift score.

2. In the first column, add 6 to each number (64 plus 6 gives the answer 70); in the second column subtract 3 from each number; in the third and fourth columns alternate between adding 6 and subtracting 3.

3. Same procedure as above, but in this case add 14; subtract 7; alternate between the two.

4. Add 17; subtract 13; alternate.

5. In the first column add 1 to each number; in the sec-

ond subtract 1 from each number; in the third and fourth alternate between adding 1 and subtracting 1.

The above tests were given to groups of school children and adult university students. The tests were given by the group method; time was the variable score; the measure of time was a large laboratory stop clock. Each subject upon finishing the assigned task would enter his time score upon his blank. The tests were given to small groups, either to laboratory sections, or, in the case of the school children, to divided classes. Since there was a limited number of subjects in each group tested, it was possible for the experimenter and the monitors who assisted him to check up the individual time entries.

It was necessary in the case of each of the above tests to correct for errors in calculation. All the problems were checked and the number of errors entered for each column. The formula used in correcting for errors was $t/n \times (n + E)$, in which t represents the original time entry, n the number of items in the assigned task, and E the number of errors. To illustrate: In a given column of problems containing 25 items, the time score as entered was 50 seconds, the number of errors 2. Substituting in terms of the formula the final score will be $50/25 \times (25 + 2)$, or 54 seconds. This formula imposes a penalty for each error equivalent to the average time required for doing each item in the column. In correcting the shift tests, each failure to alternate from one type of problem to another was counted as an error.

The first two tables below give the median scores obtained by 70 Barnard students in the first four tests described above. The subjects were divided between the Shift First and Shift Last procedures. The caption "S. T." indicates the score made in the separate tasks, "Shift" indicates the score made

TABLE I

	Add-Multiply	*+6—3*	*+14—7*	*+17—13*
		Shift First		
S. T.	58 (7)	85 (15)	140 (19)	167 (28)
Shift	93 (12)	115 (15)	183 (36)	224 (51)
		Shift Last		
S. T.	64 (10)	84 (13)	146 (27)	164 (46)
Shift	88 (17)	116 (22)	169 (37)	187 (48)

in the shift performance. The measure of varability, Q, is given in parentheses.

To get a measure of the interference effect of shift, each individual's score in the separate tasks was subtracted from his shift score and this difference in turn divided by the separate tasks score to give the percentage of time required by the shift performance over and above that required in doing the separate tasks. We shall hereafter refer to this measure as the "per cent loss" score. The individual per cent loss scores were cast into a new distribution, the median scores appearing in the table below. The first two figures in TABLE II give the median per cent loss scores for each of the two procedures, and the third gives the median for the entire number of subjects combined. The measure of variability, Q, is again given in parentheses.

TABLE II

Median Per Cent Loss

	Add-Multiply	*+6—3*	*+14—7*	*+17—13*
Shift First	61 (24)	33 (16)	24 (18)	32 (13)
Shift Last	44 (19)	34 (13)	15 (14)	10 (11)
Combined	54 (19)	34 (13)	21 (15)	22 (13)

The results appearing in TABLE II show the necessity of presenting the tests according to the two procedures. With the more difficult problems there is a carry-over of practise from the part of the test first performed, either according to the Shift First or Shift Last procedure, to the second part. This effect appears even though there are no duplicate numbers in the columns, and therefore no problem occurs twice. (It can easily be seen, however, that to add 17 to 67, for example, will have a practise effect on a later problem where 17 must be added to 87). The use of the Shift Last and Shift First procedures provides the best possible means of equalizing these practise effects.

Groups of school children, from grades 6B to 8A, including a total of 80 subjects, were given the first two of the problem situations represented in the tables above. All of the subjects did the first test according to the Shift Last procedure, and in the second half the number of subjects followed the Shift First, the other half the Shift Last procedure. The results are presented in TABLE III. The third entry in each column of the table gives the per cent loss scores obtained from the individual records.

TABLE III

	Add-Multiply Shift Last	*+6—3 Shift Last*	*Shift First*	*Combined*
S. T.	108 (21)	192 (50)	210 (40)	199 (48)
Shift	169 (40)	229 (58)	317 (91)	269 (77)
% Loss	53 (19)	17 (13)	57 (20)	33 (16)

The only significant differences appearing in the results from the group of children as compared with the adult groups is the decided increase in amount of time required by the former to complete the same problems, and the more noticeable practise effects demonstrated by a comparison of the per cent loss scores resulting from the two procedures in the "Add 6, Subtract 3" problem situation. A very significant similarity in the results from the adult and children groups appears above these differences. It is noticeable that the shift loss is decidedly greater in the case of the test presenting the easiest problems. Our measure of difficulty in this case is the time required to do the problems. It will be seen from TABLE II that the easy "Add-Multiply" problems stand in marked contrast to the more difficult problems; in going from problems of the second to the third and fourth degrees of difficulty this decrease in per cent loss with increase in difficulty is not so pronounced.

The finding that shift effects decrease with increase in the difficulty of the problem elements suggested an approach to the problem of mental set and shift involved. In order further to test this finding, a second test series was given to a group of 22 adult students who had not served in the tests represented in the foregoing tables. The following tests were given in the order named: first, the test calling for adding 6 and subtracting 3; second, the "Add-Multiply" test; third, a test presenting even less difficult problems, calling simply for the addition of 1 to each number in the first column of the blank, the subtraction of 1 from each number in the second column, and for alternation between adding 1 and subtracting 1 in the third and fourth columns. Half the number of subjects followed the Shift First, the other half the Shift Last procedure. The results from the two groups combined appear in TABLE IV.

TABLE IV

Shift First and Shift Last Combined

	+1—1	*Add-Multiply*	*+6—3*
S. T.	49 (4.3)	58 (8.5)	80.5 (7.5)
Shift	81.5 (16.3)	88.5 (9)	110.5 (28.5)
% Loss	69.5 (22.5)	50.5 (19.5)	38.5 (12)

The results presented in TABLE IV again demonstrate that shift has the most damaging effect when introduced into easy problem situations. Let us consider the explanations that can be offered for this phenomenon.

In the historical survey we noted that certain investigators had found evidence of a special factor, variously called the Perseveration factor, and the Faculty of Attention, analogous to what may be called, in the present study, the Ability to Shift. On the theory that such a factor exists, we might analyze the performance involved in a shift task into three distinct processes. Where the shift task combined two separate activities, we would have in the present case (1) an associative response to one type of problem, such as that of adding two numbers; and (2) an associative response to the second type of problem, such as multiplying two numbers; besides this we would have (3) the act of shifting from one type of response to the other. On the supposition that this act of shifting is a function by itself it might be supposed that it remains more or less a constant factor in the various problem situations. The score in a shift performance would then reduce the following formula: $na + nb + nk$, in which n stands for the number of problem items in the test, a represents a problem item of one type, b a problem of the second type, and k the act of shifting from one problem to the next. Now take one case in which a and b represent easy problems, and another case in which they represent more difficult problems: if in both instances k enters in as a constant factor, the loss through shift will be relatively greater in the case of the easy problems. It is the old story of measuring a man and a boy on a pedestal. The boy is the easy problem situation; the man the more difficult problem situation; the pedestal the constant shift factor. The pedestal will affect the height of the boy relatively more than the height of the man.

But formulae and pedestals are misleading, as are the concepts of "Perseveration factor" and the "Faculty of Attention." Let us consider another explanation.

No task, however simple, is without its elements of shift. Take the case of adding or of multiplying the two digits in a column of two-place numbers. Each of these tasks constitutes a highly practised performance. As we pass through the column of numbers, we not only have to do each separate problem, but we must also pass rapidly from one problem to the next. Here also is a case of shift, shift within the same uniform type of task. Our skill in addition, for example, consists in part in our ability to respond to the separate problems and in part in our ability to adapt ourselves to the next problem without interrupting the smoothness of the operation. Our progress through the column has a high degree of automaticity. The same holds true for the task of multiplying the two digits in each number. But when the separate tasks of adding and multiplying are thrown into one performance, calling for alternation between the two types of response, a highly unpractised situation is introduced. The aid of practise which obtains for the separate tasks is vastly greater than the practise we have had in doing the shift performance. Consequently a marked amount of shift loss results. We need not assume that the shift involved in doing the alternate problems is different in kind from the shift involved in doing the separate tasks. The difference can be reduced to the degree of practise of the particular shift activity involved. In other words, according to this view, if one were as highly trained in adding and multiplying alternately as one is in doing each type of problem consecutively, one might suffer no loss at all in doing the shift columns.

But how does this explain the greater relative loss sustained by the easy as compared with the more difficult problems? The answer is again given in terms of practise. The operation of adding 6 and subtracting 3 from two-place numbers, for example, is less practised than that of simply adding or multiplying two digits. When one passes from adding 6 consecutively or subtracting 3 consecutively to doing the two problems alternately, one invites a performance which is even less practised, it is true; but the difference in practise between the two procedures is relatively less than the corresponding difference in the easy problem situation. The less practised the single elements that comprise a given task, the less practised will be the form of adaptation required in shifting from one element to the next. And so to introduce new shift elements into the relatively unpractised performance results in relatively only a small amount of loss.

To summarize: The more highly one has become adapted to shift from one element to the next in a uniform activity, the greater will be the loss when shift between elements of this activity and another activity is required. And as corollary, the less practised the separate tasks as compared with the shift tasks, the less loss will the latter entail.

The explanation here proposed is in accord with observations that can be made from other fields. It is a commonplace in psychology that to change a feature in a well-established habit will have a more disturbing effect than to break into a habit which is not so deeply ingrained. The associative and retroactive interference effect of old associations is greater than that of associations less strongly intrenched. Similarly, as compared with a well-trained habit, a relatively new and unpractised activity will appear to a decided disadvantage. The constituent elements of the former have become thoroughly integrated, whereas in the latter they require more deliberate adaptation; that is, they entail more shift. If the old and the new habits were compared at their early beginnings, they would appear to equal advantage. In the present case, the simple calculation tasks are of the nature of well-trained habits as compared with the new activity of alternating between two types of problems; hence the high inefficiency of the latter as compared with the former. The more difficult problem tasks, taken separately, and the shift task combining two types of problem activities are more nearly equal on the score of previous training; accordingly, the high differences in efficiency do not appear.

The above account brings into the problem of set and shift the concept of practise effects as opposed to the *a priori* assumption of a special shift factor. It proposes the view that every activity, however uniform and simple, calls for adaptation and adjustment, and that a rigid line cannot be drawn between the shift involved in one situation as compared with another. It should be noted in particular that the general principle here stated is not that the easier the task, the greater will be the loss through shift. It is true in the case of the present tests that the simple number work shows the highest shift loss, but the explanation of this finding is given not in terms of the speed of the separate reactions to each stimulus item but in terms of the practise effects which obtain in operating with a series of problems as a continuous uniform performance. We shall have occasion to see in subsequent parts of this study that shift effects are not directly proportional to the degree of difficulty of the separate test responses. The key to the present account lies in the relative amount of shift that prevails in the single task operation as compared with the added shift entailed in combining two or more simple tasks into one performance. We leave this point for the present to consider the results from other tests.[9]

Controlled Association

For this experiment two equivalent lists of stimulus words for the naming of opposites and verb-objects were taken from the Woodworth and Wells test series. The procedure was as follows: A list of twenty words was given to the subject with instructions to name for each one a word of opposite meaning; a list of twenty verbs was presented with instructions to name an object for each one (thus, answer-*question).* These two lists constituted the test of the separate tasks.

In the shift performance the words from two equivalent lists were combined into one test. The first word was a stimulus for the naming of an opposite, the second an object, the third an opposite, and so on in alternation between the two types of associative response. The forty words were presented in two equal columns. Separate time records were taken for each column, and a few moments were allowed to intervene before the subject went on with the second column after having completed the first.

Since there were two equivalent lists of association words it was possible to present two arrangements of the material. Designating the two lists as Opposites A and B, Objects A

[9] A word should be given with regard to the reliability of the measures presented in the foregoing tables. As to the scores in the separate tasks, an approximate measure of reliability can be found by correlating the individual scores in the first column with the scores in the second column of each test. For the adult groups this procedure gave an average correlation of .80; for the group of children, .83. A direct measure of the reliability of the shift scores within the same test could be obtained by correlating scores in the first of the two shift columns with scores in the second; the average coefficient so obtained for the group of adult students in the four problem situation was .86.

and B, the arrangements were: (1) The two A lists separately as tests of the separate tasks, the two B lists combined to form the shift test; (2) B lists used as tests of separate tasks, A lists used in the shift test. Each subject was required to respond to both test arrangements, thereby completing two trials of the test. As a precaution against any differences in difficulty that might obtain for the two arrangements, half the number of subjects were first presented with the first arrangement, then with the second, and the other half were first given arrangement (2).

The tests were given to 34 Barnard students, members of a class in beginning psychology. The group was divided between the Shift First and Shift Last procedures. The tests were all given individually by the experimenter. The responses were called orally, and in case of error the subject was stopped and required to make a correction. Time was taken with a stop watch.

The tables below give the results obtained from the two groups. The median scores are presented, with Q as the measure of variability. The per cent loss scores are in this case also derived from the individual and not from the group records. The third column in each table gives the combined scores from the two trials of the test.[10]

TABLE V

Naming Opposites and Verb-Objects

	Trial 1	*Trial 2*	*Combined*
	Shift Last		
S. T.	50 (4.5)	52 (6.5)	102 (13)
Shift	64 (6)	54 (7.5)	120 (13.8)
% Loss	26 (12.5)	5 (10)	16 (5.3)
	Shift First		
S. T.	53 (5.3)	46 (4.8)	98 (10)
Shift	60 (9.5)	48 (4)	107 (12)
% Loss	21.5 (7.3)	3 (7)	11 (7.3)

TABLE V shows that the loss effected by shift in controlled association is relatively small on the first trial and almost disappears on the second. The per cent loss figures for the five calculation tests (TABLES II and IV) were as follows, going from the easy to the more difficult problem situations: 69.5, 54, 34, 21, 22. The per cent loss in the first trial of con-

[10] The reliability of the shift scores, obtained by correlating scores from the two shift columns, was $r = .78$ and .84 for the two procedures.

trolled association is decidedly less than that of the two least difficult, and approximately equal to that of the two most difficult of the problem situations.

A comparison of the results from the Shift Last and Shift First procedures shows that an initial test of the separate lists tends not only to increase the absolute scores in the shift test but also increases the percentage of loss. There is evidence here of the operation of a mental set: preliminary practise with the separate tasks arouses a mental disposition antagonistic to the mental set required for the shift lists. The interference effect is not great, to be sure, but it further bears out the statement earlier made that the more practised the uniform operations that go into a shift performance the greater will be the shift loss.

That shift has a retarding effect on controlled association is definitely demonstrated by the figures giving the percentage of loss sustained in the first trial. The corollary of this is that a mental set operating with a uniform series of association stimuli has an accelerating effect. The accelerating influence of a mental set has been well demonstrated in studies that have compared free with controlled association: the latter usually proceeds more speedily than the former. However, in the present case the difference between the time required by the separate as compared with the shift lists does not reduce to a difference between free and controlled association. The shift list calls for more 'control' than do the separate lists: it presents a more complex stimulus in that the subject must not only operate with a set for naming each of the two appropriate types of response, but must also have a set for alternating between the two.

It is somewhat surprising to note, in the first place, how little the performance is retarded by this added mental set; and, in the second place, how quickly the subject adapts himself to the shift situation. On the second trial the hindrance effect is reduced almost to zero. It is clearly shown that practise plays an important role in determining the relative speed of the shift performance. Yet to infer that the rapid recovery from the harmful effects of shift is due solely to practise in this case would be to leave out an important consideration. We pass on to another aspect of the problem.

In order to test the effects of shift under conditions differing from those described above, a variation in procedure was introduced. In this case the two types of stimulus words comprising the shift test were placed not in successive alternate arrangement but in two adjacent lists. The subject was still required to alternate between the two types of response, but in this case he had the aid of spatial associations: he would respond first to the first word in one list, then to the first word in the second, then to the second word in each list, and so on. Moreover, instead of giving oral responses the subject was required to respond in writing. In order to effect constant spatial factors, the separate association lists were similarly broken into two adjacent lists and the subject required to move from one to the other, responding to successive words.

The results from a group of thirty subjects who were given this test are as follows:

S. T. 92 (9.5) Shift 94 (10) % Loss 2 (6)

The high variability of the per cent loss score arises from the fact that some subjects made a gain, others a loss in doing the shift test. The results show that the added feature of adjacent lists and writing reduces the shift loss almost to a median of zero on the first trial.

That shift between two types of associative response calls for an added initial display of energy above that required when only one mental set is operative cannot well be questioned. The objective results, especially as they appear in the paragraph immediately above do not give a clear picture of the added effort involved in doing the shift task. The immediate effect of introducing added shift elements into a performance is to add to the novelty of the task and therefore, in a measure, to increase the difficulty. There may be a dynamogenic effect in the increase in difficulty that overcomes in part the loss that would otherwise occur. It is not possible to measure the efficiency of a performance solely in terms of time required for its completion. On this point more will be said in subsequent parts of the study. For the present let us consider other factors which enter into the performance.

In their analysis of the processes involved in responding to continuous lists of association stimuli Woodworth and Wells[11] point out that two opposing factors are operative in influencing the speed of the responses. In the naming of opposites, for instance, the overt response is the verbalization of the appropriate word. This verbal response, however, pro-

[11] Psych. Rev. Monog. Suppl. No. 5, 1911.

ceeds quite automatically once the necessary preparatory reactions have been made. So while the subject is still responding to one stimulus he can already be occupied with the next. In other words, the responses overlap. Overlapping has an accelerating effect.

The other factor is that of interference. In reading through the list of words, the subject must carry the cumulative effect of associations, both relevant and irrelevant, that have been aroused by previous stimulus words. These associations have an inhibitory influence and tend to retard the response time.

From this analysis we again meet the consideration that even within the operation of a given mental set there is an element of shift. Each new stimulus, each successive response, calls for a new adjustment differing to a greater or less degree from those which have preceded.

Now take the case where two association sets must be combined in one performance. The subject responds now with an opposite, now with an object, and so on. On the one hand, it is to be supposed that the factor of overlapping will be just as effective in this operation as it is in the separate association lists. In other words the accelerating effects will remain constant.

On the other hand, to the interference effects of the separate lists is added another source of interference when we come to the shift lists; namely, the necessity of shifting from one type of associative response to another. This added interference makes for a loss in speed in the case where the alternate types of response follow each other in the same column. The loss in speed is not, however, as conspicuous as might be expected in view of the results obtained from the calculation tests which we have previously considered. It would appear that the added interference entailed by shift has a counter influence upon the interference effects that obtained in the separate lists.

An experiment performed by Pedrick, cited in the study made by Woodworth and Wells, shows that the reaction time to the separate words in a continuous list of association stimuli is prolonged as the subject proceeds farther and farther into the list. The irrelevant associations, which make for interference, gather force with each successive response. But a counter-factor may be at work when each successive word requires a different type of response. The associations necessary to effect the shift from one type of response to another would have the effect of ruling out other incidental associations. A higher and more comprehensive mental set is required when each alternate word calls for a distinct set of associative material. The cortical tension is increased, the threshold for irrelevant associations is heightened. This may explain in part the fact that to combine two mental sets into a single and more complex activity is in no way comparable to doubling the time requirement of the performance. That adaptation to the more complex activity is speedily accomplished is seen from the fact that after one practise trial the rětarding effects of shift almost entirely disappear.

Controlled Association and Calculation

In the foregoing sections it was demonstrated that shift introduced into calculation tests and test of controlled association resulted in both cases in a loss in efficiency. In the present section we shall see what is the effect of combining calculation and controlled association into one shift performance.

The test here considered was presented on prepared cards containing the following items: A column of 25 words, stimuli for the naming of opposites; a column of 25 two-place numbers, from each of which the subject was to subtract 3; on the other side of the card, two columns containing the same word and number items arranged in alternate order, requiring shift between the naming of an opposite and calling the appropriate answer to the problem of subtracting 3 from the given number.

This test was used in a practise experiment calling for continued use of the same test material. As a precaution against memorization of the order in which the test items appeared the material was presented in four different arrangements.

The subjects worked in pairs, each member of the pair having a different set of words and figures. Subject A would first respond to the separate association and calculation columns while B kept a record of the time and checked the responses, calling for correction of errors whenever any were made. Following this, Subject B would respond to the separate task columns of her test. Subject A, and then B, would do the shift test, thereby completing the first trial. On the second trial each subject would proceed as in the first, using a card containing the same test items in a different arrangement. On the fifth trial the card used for the first trial would again be used.

Time was taken with an ordinary watch; to make for accuracy in timing, the signal to start was given when the second hand stood at 60. Eighteen subjects served in this experiment, completing 16 trials. The practise effects will be considered in another section. Our present concern is to note the effects of shift in the test here described as compared with shift between two types of calculation problems and two types of controlled association.

In all of the sixteen trials the *shift* test was in the lead: it required less time to respond to the 50 alternate problem and association stimuli than to respond to 25 successive association words and 25 arithmetic problems arranged in columns by themselves. The Shift Last precedure was used on the first trial of the test and for that reason the results of this trial show a decided advantage for shift. But if we take the average time for the first and second shift trials, and the average time for the second and third trials of separate tasks, thereby giving the latter the advantage of added practise, we have the following results, with the A.D. of each average given in parenthesis.[12]

S. T. 51 (9.4) Shift 48.6 (9.7)

The figures here presented show a small but reliable gain for the shift task. In other words, to shift between naming opposites and subtracting 3 results in a gain in time, whereas to shift between naming opposites and verb-objects on the one hand, and subtracting 3 and adding 6 on the other (TABLE II) results in an initial loss. It is here shown that shift does not invariably entail a loss in efficiency; that two mental processes calling for judgments of a different kind can operate together without causing diminished performance.

We have already introduced the factors of overlapping and interference in connection with the experiment on controlled association. It appears that these factors can be called upon to good advantage to account for the findings in the present case.

Overlapping, it was seen, accelerated the response process by permitting the subject to go on to the next stimulus while still giving the overt response to the first. Associative inter-

[12] The self-correlation of the two trials of the shift test was 84.

ference, on the other hand, retarded the process. Consider in the light of this the present test situation. In the alternate word and number stimulus items, we may suppose that overlapping is operating at full force. Interference, on the other hand, is reduced; the alternate arithmetical problems break the chain of irrelevant associations engendered in the separate association lists. The reduction in interference is strong enough to outweigh the added burden of having to shift from one type of response to another.

Another significant feature should be added. Shift between number and word stimuli is aided by the fact that each successive stimulus suggests in a measure the type of response that is to be given. One cannot name an opposite for a number, nor subtract 3 from a word. In the case of shift between calculation problems the successive numbers serve equally well as stimuli for one type of problem response as another. In the case of successive word stimuli in controlled association the two types of stimuli are not so sharply defined as in the present case. It was seen in the case of controlled association that when the two types of stimuli were placed in separate columns the result was practically no shift loss. From this observation and from the results of the present test it would appear that the shift performance is greatly facilitated by the aid of associations that inhere in the spatial arrangement of the stimuli or in the nature of the stimuli themselves.

Even with this consideration it is still necessary to call into account the factors of overlapping and interference which have been mentioned above. In the test of calculation and association the nature of the stimuli can account for the fact that no shift loss is entailed. But in order to account for a gain for shift, other factors must be introduced.

The consideration that shifting is facilitated by stimuli that are visibly different has an important bearing upon the observations made in connection with the calculation tests. If the shift factor is so negligible that its effects are overruled by the associative aid here in question, we are once more brought to the inference that shift does not exist as an act *per se* but is an integral part of the adaptational process involved in all types of mental activity, whether this activity be of a uniform or of a more complex character.

In the sections which follow we shall have further opportunity to study the effects of shift in materials where the stimulus items are visibly different.

Color Naming. Form Naming

In these experiments the well-known Woodworth and Wells color naming and form naming blanks were used. The color naming test will first be considered. It contains 100 colors, twenty each of black, blue, red, yellow, green, so arranged that no ordered patterns can be detected in reading off the color names. As such it is to a large degree a test of ability to shift; for this purpose it was used in the present experiment.

In what we shall call the test of the separate processes, the subject was presented with the blank and told to read each color separately, pointing to each one with the blunt end of a pencil. In this way the subject would go through the blank, reading first all the reds, then the greens, blues, blacks, and yellows. To read the five colors it was necessary, consequently, to read through the entire blank five times. The subjects were required to read continuously, *i.e.*, as soon as the reds had been read they would return at once to the top of the blank and read the greens, and so on with the five colors.

In the shift test the color naming blank was presented in the usual way; the subject was required to respond to the color items in the order in which they appear on the blank. In this case also the subject was required to point to each color as it was read in order to keep this condition constant for the two tests. Persons who have given the color naming test will have observed that many subjects resort to pointing even when no instructions to that effect are made. Since the tests were given individually by the experimenter and a colleague, it was possible to check the responses and to call for corrections of errors and omissions. Time was taken with a stop watch.

The same procedure was followed with the form naming test. As a test of shift the form naming blank was presented as it is usually given; in the test of the separate processes the subject was required to go through the blank five times reading only one form each time. Pointing was required in this test as in the foregoing.

Twenty-eight Barnard freshmen served as subjects in this experiment. Half of this number were given the tests according to the Shift First, the other half according to the

Shift Last, procedure. TABLE VI gives the average time for the two combined groups, with A.D. as the measure of variability. The average "per cent loss" was derived by finding for each individual the amount of gain or loss shown by the score in reading the blank as a whole as compared with the score in reading the colors and forms separately.

TABLE VI

Shift First and Shift Last Combined

	Color Naming	*Form Naming*
S. T.	55.6 (7.3)	72.9 (9.6)
Shift	56 (6.3)	80.4 (9)
% Loss	.4 (12.1)	11.2 (11)

It will be seen that both in color naming and form naming there is an average loss for the reading of the blank as a whole. In both cases the variability is high, since some subjects showed a gain, others a loss. In other words, to go through the blank five times, pointing and naming each color and form, required less time than to go through each blank only once, reading the colors and forms in the order in which they appear.

Here again we are met with the fact that even within the same general mental set there is a decided element of shift. We have in this case a set for naming colors consecutively, and a set for naming forms consecutively. But since there are five colors and five forms in each blank, the naming involves continued shift from one visuo-lingual response to another. This fact is further borne out by the results from an experiment in which color naming and form naming were combined into one test. We postpone further discussion to take up this experiment.

Color Naming and Form Naming

This test was designed to discover shift effects from combining both color naming and form naming into one operation. Fifty colors and fifty forms, or, in other words, half the number of items of the regular color and form naming blanks constituted the test of the separate processes. The shift test consisted of fifty colors and fifty forms pasted upon a card, the spacing being the same as in the regular blanks, so arranged that each form alternated with a color, calling for shift from one type of response to the other.

The test here described was used in a practise experiment in the Barnard laboratory. In order to guard against memorization of the order in which the items appeared, each subject was given two copies of the test, each of which contained the same stimulus items arranged according to different patterns, and each of which could be turned upside down to present these items in the reverse order. In this way four arrangements of the same material were given to each subject.

The subjects worked in pairs, alternately acting as subject and experimenter. One of them would do her test while the other kept time and checked the responses, calling for a correction if an error or omission were made. Sixteen subjects served in this experiment, completing 15 trials. Time was taken with the second hand of an ordinary watch. The results of the first two trials combined, giving averages and average deviations, appear in TABLE VII. The high variability of the per cent loss score arises from the fact that some subjects showed a gain, others a loss, in the shift test.[13]

TABLE VII

Color Naming and Form Naming

S. T. 52 (3.4)	Shift 55.8 (4)	% Loss 6.2 (8)

It should be remarked that the procedure in this test is not directly comparable to that used in the experiments where the shift effects within the separate color and form naming blanks were studied. Yet it is rather striking that in the present procedure alternation between color naming and form naming shows only a slightly higher percentage of loss than shift within the color naming test alone, and decidedly less loss than that demonstrated by the form naming test.

The results from these tests raise interesting problems. In order further to arrive at an analysis of the factors involved, a new test was devised. Each subject was given a typewritten blank containing the names of the 100 colors of the color naming blank and was required merely to read off the words. The average time for this test was 36.4 seconds, with an A.D.

[13] The measure of reliability of shift scores, obtained in this case by correlating scores in the first and second trial gave a coefficient $r = .73$.

of 2.9. This figure, compared with the color naming average of 55.6 seconds (TABLE VI), gives a difference of 19.2 seconds between naming colors and naming the corresponding color names. What makes for this imposing difference?

In a study of the difference between the time required for color naming and word naming Lund[14] put both processes to an experimental test with subjects of varying ages. The results showed that children who have not had a great amount of practise in either performance required just as much time for word naming as for color naming. One subject, a child of five, made a better record in *color* naming than in *word* naming over a practise period of 100 trials. In other words, the difference in time for color naming and word naming for adult subjects reduces to a matter of greater practise in the naming of words. The adult is not only more practised in reading the separate words but is also more practised in reading continuously through a series of words. The shift element, consisting in the type of adjustment necessary in passing from one word to the next, is reduced to a minimum through long continued practise. The child, on the other hand, is confronted by an unpractised performance when presented with the word blank. He operates with each word as a unit, and passes haltingly from one word to the next. He lacks skill not only in responding to the separate words but also in telescoping his responses into a smooth performance. The task contains for him a high degree of shift.

This provides us with a key to the findings in the present experiments. The difference between word naming and color naming is due to a difference in training. The difference in the time required in reading the consecutive colors of the color naming blank as compared with reading through the blank five times, naming only the items of one color each time, is due to lack of practise in shifting from one color response to a response to a different color. Similarly for the form naming test: each successive form is of a different pattern than the preceding one; to read through the blank consecutively involves an element of shift less practised than that involved in successive responses to only one form pattern. Further, the relatively small amount of loss sustained in shift between color naming and form naming can be explained by the fact

[14] *The Role of Practise in the Speed of Association.* To appear in a forthcoming issue of the American Journal of Psychology.

that each of the separate tasks involves almost as much shift in going from color to color and from form to form as is involved in alternating between a color naming and form naming response. The shift effects in the separate tasks overshadow the shift in the combined operation.

In connection with the test of controlled association and calculation, the point was raised that visibly different stimuli facilitated the shift process. In the present case all of the stimulus items, both of form and of color, are visibly different, and all of them suggest the appropriate response. Yet it is seen in the case of the separate tasks that in spite of this aid there is a demonstrable shift element, and in the case of the test combining alternate form and color items the effects of shift are clearly observable. It follows from this that the efficiency of a given shift performance cannot be accounted for solely in terms of the ease with which the various stimuli can be discriminated and in terms of the degree to which each stimulus suggests its appropriate response. The observation here made substantiates the view that other factors, such as that of practise which is considered at some length above, must be taken into account.

Color Naming, Form Naming, Naming Opposites, Subtracting 3

In the section dealing with the calculation tests, notice was taken of the effect which an increase in the difficulty of the task had on the shift results. The easy calculation problems gave greater shift loss than did the more difficult. In the present section another variation is introduced. Instead of increasing the difficulty of the separate elements of the test, the number of processes between which shift must be made is increased from two to four.

The present test combines color naming, form naming, the naming of opposites, and subtracting 3. The tests of the separate processes contained 25 colors, 25 forms, 25 stimulus words for the naming of opposites, and 25 two-place numbers from which 3 was to be subtracted. The separate groups of twenty-five items were arranged on a card in the same spatial arrangement as that of the color and form naming blanks. In the shift test, the elements of the four separate tests were pasted upon especially prepared cards corresponding in size and spacing to the color and form naming blanks. In order to secure a 'random' placement of the various items the form naming blank was used as a model.

This test, like the foregoing one, was used in a practise experiment in the Barnard laboratories. As before, four arrangements of the test material were used to guard against memorization of order. The subjects worked in pairs, each member of the pair having a different set of materials. Time was taken with an ordinary watch, the subject being told to begin when the second hand was at 60. Eighteen subjects completed 12 trials of the test. The Shift Last procedure was used with all the subjects, so the first trial is not representative. The results of the first three trials, in terms of averages and average deviations, appear in TABLE VIII.[15]

TABLE VIII

Color Naming, Form Naming, Naming Opposites, Subtracting 3

Trial	*1*	*2*	*3*
S. T.	91.1 (1)	80.3 (11)	79.6 (8.3)
Shift	85.5 (15)	80.6 (13)	77.7 (12)

On the first trial, Shift shows a decided gain, due to practise effects from the preliminary tests of the separate processes; on the second trial it shows a slight loss, and on the third it moves ahead for a gain. The results from the experiment as a whole will be given in a following section; it can be stated here, however, that in nine of the twelve trials, the shift test required less time than did the test of the separate processes.

Without previous investigation one might have expected that the shift test would show a decided loss. If it is to be supposed that a given set is present in all uniform mental activity and that this set is interfered with when elements from other tasks are introduced, the present test should yield a high shift loss. Nothing approaching a logarithmic curve analogous to that found in the psychophysical studies of sensation occurs in the present case. When naming opposites and subtracting 3 are combined into one performance, the shift operation shows a slight gain; when color naming and form naming are combined, the effect is a slight loss; when the four processes are combined, the result seems merely to

[15] The self-correlation of scores in the three trials of the shift test gave an average coefficient of .87.

reduce to a matter of adding the gain from one situation to the loss in the other situation with a net effect of relatively neither a loss nor a gain. In the light of this finding it can readily be seen that too much emphasis can easily be given to the harmful effects of shift in situations that have not been put to an experimental test.

Two pertinent suggestions present themselves to account for the finding made in this experiment. One of them calls into play the concept of facilitation by reduced interference; the other makes use of the concept of dynamogenesis. We shall consider these in the order named.

Ordinarily the function of a mental set is to produce a greater state of readiness for a response of a given type. As such it becomes a part of the stimulus situation. Take the case of simply adding the two figures in a column of two-place numbers. The set for adding enters into the performance as a whole; even before the separate additions have been made the preparatory reactions are initiated by the mental set. We have seen that to introduce another task, such as that of alternate multiplication and addition, is to invite a highly unpracticed mental set; the stimulus situation presents for the moment a more complex pattern; the state of readiness for one type of response is disrupted; the result is prolonged reaction time. In this way the situation bears some analogy to the difference between simple and choice reaction time.

On this premise, why should the combination of four mental sets, such as those involved in the present experiment, give practically no loss at all? We have already discussed the factors of overlapping and interference: let us consider these again from a new point of view.

Those who have taken the color and form naming tests will have noticed an unpleasant feeling of what might be called "thwarted" mental activity in reading off the successive items. The verbal responses seem to lag behind the immediate perceptual process; the incipient reaction requires less time than the completed overt response. The difference in time between color and form naming and the naming of the corresponding words, as discussed in the section above, reduced not to a difference in speed on the receptor end of the arc but to a difference in speed on the effector phase. Sub-lingual awareness proceeds more rapidly than the overt-lingual response.

This, it will be observed, is another statement of the general factor of overlapping. The adjustment to a new type of stimulus, say that of naming a color immediately after the naming of a form, can take place in the interim. Consequently color naming and form naming show little loss in the shift combination.

In the case of calculation, however, the response to the stimulus requires more time and involves a more elaborate judgment process. The discrepancy between the incipient response and the overt reaction of simply naming the correct answer is relatively not so great. The possibilities for overlapping are reduced. As a result, the associative shift required in the unpractised mental set for alternating between addition and multiplication effects a greater initial loss than does shift in color naming and form naming. In view of this, and in view of the findings in the experiment which combined calculation and the naming of opposites, consider what occurs in the present test. The cumulative interference effects that arise in a continuous series of controlled association responses are broken by the interpolated color, form, and calculation stimulus items. The lag between the incipient and overt response to the color and form items is taken up by the interpolated association and calculation stimulus items. Overlapping is increased to a maximum, interference is reduced to a minimum. The increased efficiency so effected compensates for the added burden of carrying a mental set for responding to four different types of stimulus. The final result is what amounts to practically neither gain nor loss.

We come to the second consideration. Experiments performed to show the effects of noise and other distractions on simple reaction time and more complex forms of mental work, and experiments such as those made with the McDougall dotting apparatus go to show that a subject may work under extremely trying conditions without showing a commensurate decrease in amount of work done. Yet to suppose that the performance of a person working amid a bedlam of noises or operating with two simultaneous difficult tasks is accomplished with the same efficiency as when no distractions are introduced would be to do violence to known laws of mechanics. A given reaction is partly a function of the responding mechanism, partly a function of the stimulus. Increase the strength or the complexity of the stimulus and you increase the complexity and strength of the response mechanism called into play. Applied to the present case, the small amount of shift loss may be due not so much to influences that inhere in the associative patterns involved as to increased tension and increased activity on the cortical level.

The import of this consideration goes far beyond the practical implications of the particular test here in question. But the results of this test lead to more general practical observations. Increase the stimulus and you increase the effectiveness of the response. In many practical situations the necessity for shift from one type of performance to another is unavoidable. To the question, Does shift of this kind make for inefficiency? we answer, on the basis of the findings made so far in this investigation, that it does not much matter. The immediate loss through shift, if there is any at all, will be compensated in part by an added display of energy. And in due time the harmful effects of shift may yield to the influence of practise. We hasten to add that this rule will not apply where shift must be made between gross and mutually exclusive motor functions. In that case the factors of antagonistic muscle systems, the refractory period, the "warming up" phenomenon, and spatial circumstances have to be taken into account.

One more point should be considered. If the shift test in the present case induces greater strain and tension than do the separate tests, and if this added strain has disagreeable effects, it should be possible for the subjects to observe it. To investigate this matter, the eighteen subjects were asked to make a statement as to which test they preferred, the test calling for shift, or the test of the separate processes. Twelve of the eighteen preferred the shift test. The reasons given were that it was not so monotonous, that the variety of stimuli gave added interest and incentive. From this it can be seen that even though the shift test may call into play a more elaborate response system, even though it may constitute a greater drain upon the nervous energy, yet the added feature of shift makes for more interest and enjoyment. One might stress this point too far, but it cannot be doubted that tedium and ennui often arise partly from the fact that the individual's nervous system is not functioning to capacity. The busy man is never bored. The hard-working laborer does not have time to think of suicide. Again raising the question as to whether shift makes for inefficiency, the element of interest must be taken into account. No task which must take account of the human equation can be measured simply in terms of the mechanical difficulty of the stimulus elements themselves. A task that is too uniform, too automatic, can also become too easy. The burden of monotony and boredom, superimposed upon activities that are light in themselves, can soon convert a simple duty into an onerous task. One means of eliminating tedium is to introduce shift.

Form Naming and Substitution

The Woodworth and Wells form naming blank was used in this experiment. This blank is provided with a key to be used in the substitution test. The key contains five digits, one for each form. In the present experiment the subject was required, in the substitution test, to name the appropriate number for each form, responding orally. The form naming test consisted merely of naming the forms as they appear on the blank.

In the test of the separate processes the subject was required to name the forms of one half of the blank, and to substitute the appropriate number for each form on the second half. This test was used in a practise experiment, so to guard against memorization of order, four arrangements were presented: first, name forms first half of blank, substitute second half; second, substitute first half, name forms second half; third and fourth, turn blank upside down and proceed as in trials one and two.

In the shift test the entire blank was presented; the subject was required on the first trial to name the first form, then substitute for the second, name the third, and so on through the blank. On the second trial, substitute for the first form, name the second, then substitute for the third, name the fourth, and so on through the blank. On trials three and four the blank was turned upside down and the procedure of trials one and two repeated. In this way four arrangements of the test material were effected.

Twenty-four Barnard students served as subjects in this experiment. They worked in pairs, alternating as experimenter and subject. Time was taken with an ordinary watch, the "go" signal being given when the second hand was at 60.

The experimenter was provided with a typewritten key to check the responses of the subject and to call for a correction if errors or omissions were made. One subject was provided with the substitution key given on the regular blank; a different key was provided for the other subject.

Since learning has a decided initial effect upon the substitution test, all subjects were required to take two preliminary trials both in substitution and form naming, using the entire blank, before the experiment proper was begun.

It should be observed that this test gives maximum opportunity for the study of shift. The subject must alternate between two types of response as in the foregoing tests, but in this case both responses are given to the same type of stimulus. The same geometrical form calls now for a naming response, now for an appropriate number. The result is not only shift but also the factor of associative interference. For this reason it should be of interest to compare this test with the foregoing on the score of shift effects. The results, in terms of averages and average deviations, appear in TABLE IX.[16]

TABLE XI

Form Naming and Substitution

S. T.	83.5 (9.6)	Shift	100.5 (12.1)	% Loss	22.5 (13.2)

The range in per cent loss for the twenty-two subjects was from 3 to 52 per cent. As compared with the color naming and form naming test, the test of association and calculation, and the test combining all of these four processes, we notice in this case a relatively high percentage of loss. Yet it is interesting to note that the loss is so small. Recall for a moment the results from the calculation tests in five degrees of difficulty; with adult subjects the following respective median per cent loss figures were obtained: 69.5, 54, 34, 21, 22. To shift between adding 1 and subtracting 1, between adding the two digits and multiplying the two digits of the two-place numbers, gives a respective loss of 69.5 and 54 per cent as compared with 22.5 per cent in the present case. How can this difference be explained?

A further word should be said concerning associative interference. The same stimulus item in the form naming and

[16] The correlation of shift scores of the first and second trial of this test gave a coefficient $r = .82$.

substitution test must serve for two widely different responses. The same holds true, to a large extent, also for the calculation tests. The two digits in each two-place number lend themselves equally well to the addition of 1 as to the subtraction of 1, to the addition of the two as well as to their multiplication. So on the score of associative interference, the two situations are analogous to a large degree. The difference in shift loss must be accounted for on other grounds.

We have already stressed the point that a relatively uniform operation, such as that of continually adding the two digits in successive two-place numbers, becomes quite automatic through long-continued practise; and that the more practised the continuous reactions to the separate problem items, the more shift loss will occur when the continuity of the performance is broken by the introduction of problem items of another kind. We noted also in the foregoing section that the simple task of merely reading off the consecutive items of the form naming blank involved a large element of shift. The same holds true, we may suppose, for the substitution performance. So in the case of the easy calculation tasks, the introduction of new shift elements entirely disrupts the high automaticity of the separate mental sets and yields a high amount of loss. But in the case of form naming and substitution, the added shift entailed by combining the two performances into one test is partly clouded by the shift elements which inhered in the separate tasks taken by themselves.

The findings in the present case bear upon a problem which we have previously considered. It was noted that there was a marked contrast between the shift effects in the very easy as compared with the more difficult calculation tests. One explanation for this, tentatively offered, but rejected in the face of other considerations, was the concept that the shift process may be regarded as a more or less distinct operation. On this premise it was pointed out that in a case where the separate stimulus elements required only a brief time interval, the time required for the shift activity would loom relatively larger than in the case where the separate problems required more time for solution. This explanation, if accepted, would lead to the general principle that the easier the separate reactions in a given performance, the greater would be the shift loss. But we had occasion to reject this conclusion in favor of the view that the more completely the shift effects within a uniform operation had become submerged through the influence of practise, the greater would be the relative inefficiency of a shift performance requiring an unpractised form of adaptation. The results from the form naming and substitution test tend further to discredit the former hypothesis.

There are 100 items in the form naming and substitution test. The average time required in doing this test on the first two trials (see TABLE IX) was 83.5 seconds, or less than 1 second per item. The arithmetic tests contained 50 items; the average time in the easiest problem situation was 49 seconds (TABLE IV) or about 1 second per item, and in the next to the easiest the average time was 58 seconds (TABLE I) or slightly more than 1 second per item. The per cent loss in the former was 69.5, in the latter 50.5. Compare this with a loss of 22.5 per cent in the form naming and substitution test. The time requirement per item in the two calculation tests is greater than in the present test, and yet the per cent loss in the easiest problem situation is more than three times as great and in the next to the easiest more than twice as great. It can be seen from this that shift loss does not increase in proportion to the ease with which a given task is performed, as measured by the speed of the separate elements between which shift is made.

The findings in the present case suggest again the view that shift cannot be regarded as an isolated factor, and that the type of adjustment required in doing a shift test does not differ widely from the adjustments required in doing an apparently uniform activity. That the type of adjustment involved in going from one form to the next in the form naming test calls for a relatively unpractised form of shift can be seen from the discrepancy between the time required for reading the form names from a typewritten sheet and the time required in naming the forms. A similarly unpractised type of adjustment, we may well suppose, prevails in the substitution test. Consequently, the difference in practise between reading forms and substituting consecutively and in responding to them alternately is not so great, and a relatively low percentage of loss is demonstrated by the shift performance.

Cancellation. Adding by 2's and 3's

Two more experiments that were performed should here be considered briefly. One of them, a test of cancellation, presented the following situation: The Woodworth and Wells number cancellation blanks were used. On one blank the subject was required to cross out each of the five 5's that appear in each line of the blank; on the second blank, to write a circle around each 4; on the third and fourth blanks, to cross out the 5's of the first line, encircle the 4's in the second, and continue in this way through the two blanks, alternating between crossing out 5's and encircling 4's. Thirty subjects took this test. The results showed a median per cent loss of 2 per cent for the group.

In the test of adding by 2's and 3's, the following conditions obtained: count by 2's in writing as quickly as possible (thus, 2, 4, 6, 8, etc.); count by 3's in writing (3, 6, 9, 12, etc.); in the shift test, combine both operations and alternate between the two (2, 3, 4, 6, 6, 9, 8, 12, etc.). The time limit method was used, 30 seconds being allowed for the separate performances, and 60 seconds for the shift test. The number of subjects was 33. As might be expected, the shift test showed a decidedly lower score than did the separate tasks.

The results of the two tests here described were obtained mainly to provide data for subsequent parts of the present study.

Discussion of Results

We are now in a position to bring together the results from the various experiments, to answer some of the questions raised at the beginning of the study, and to come squarely to terms with the various hypotheses that have grown out of the findings. The results from fifteen different tests have been considered. At one extreme is a test showing a shift loss of almost 70 per cent; at the other a test showing a slight percentage of gain for shift. From this wide range of results it should be possible to reach certain definite conclusions on the problem of mental set and shift.

First of all we can make the general statement that shift does not invariably involve a loss in efficiency, that the loss effected by shift varies considerably in various combinations of tasks, that in some cases it makes for a gain in efficiency.

In accounting for these differences in shift effects various explanations have been suggested. We can consider these under three main headings.

According to one explanation, the effects of shift vary with the degree to which the elements between which shift is made contain in themselves cues to the type of response required. Shift between stimuli that were visibly different and readily discriminable made for only a slight loss in efficiency. Shift between stimulus items that were placed in separate spatial settings, thereby providing an associative cue to the type of response required, likewise made for only a slight shift loss. On the other hand, where the stimuli for the activities involved in the shift performance were not clearly differentiated, a high shift loss would occur. Illustrative of the first condition was the test of controlled association and calculation, in which the word and number stimuli were easily discriminable; the test of color naming and form naming, in which the stimuli were visibly different; and the test of controlled association in the case where the two types of stimulus words were placed in separate columns. None of these tests showed a conspicuous shift loss. Illustrative of the second condition were the calculation tests, in which different types of responses were required by number items similar in appearance: each number lends itself equally as well to one type of problem solution as to another; the test of form naming and substitution, in which the same type of stimulus must serve for two different types of response, and the test of controlled association in the case where the successive word-stimuli for the naming of opposite and verb-objects were placed in the same column. These tests all showed conspicuous shift effects. In the first condition, shift was facilitated by the visible cues to the different types of response; in the second condition, where no such cues appeared in the objective stimuli, the shift burden had to be carried by an internal disposition providing for different forms of response to undifferentiated stimulus items.

The hypothesis that shift is facilitated by such factors as the discriminability of the stimuli between which shift must be made and associative aids inhering in the spatial arrangement of the stimuli, and retarded when no such associative aids are present, carries considerable weight. But if we try to apply this principle in a thorough-going way it falls down on several points. It does not account for the fact that the easy calculation problems show greater shift loss than do the more difficult; nor for the differences in shift effects in form naming and substitution and in controlled association as compared with each other and as compared with calculation. It does not explain fully the fact that shift between naming opposites and subtracting 3 is more efficient than shift between color naming and form naming. The stimulus items are easily discriminable in both tests. Even to grant that the word and number of items of the former test show greater visible difference than do the colors and forms would still leave unexplained the fact that shift in the former test resulted in a gain in efficiency. Moreover, the fact that the form naming and color naming tests when taken separately demonstrate a noticeable shift element goes to show that even in a uniform activity in which the successive stimuli are clearly differentiated there are adaptations other than those of simply responding to the separate stimuli involved in a given task.

A second explanation grew out of the findings obtained from the calculation tests. The easiest problem situations gave the highest shift loss. This suggested the view that the process involved in shifting from one task to another might be regarded as a distinct activity, a special factor, and as such a separate time consuming element. Accordingly, in the case where the problems were easy, that is, where each successive response required only a brief time interval, the time required in shifting from one response to the next would loom relatively large. In the case where each of the separate problems required more time, the shift interval would be small in comparison. The act of shifting from one response to the next would be no more difficult in itself in one situation as compared with the other, but the time consumed in shifting would be relatively greater in the easier problem tasks.

That this explanation covers the findings to a certain degree cannot well be doubted. It would be possible to assign two types of mental tasks, each one so time-consuming in itself that the time required in shifting from the one to the other would be almost negligible. But when we try to apply this principle as a general rule, we run into serious difficulties. In the case of form naming and substitution, for instance, the separate responses required less time than did the responses to the separate problems in the easiest calculation test. Yet the shift loss in the latter was more than three times as great as in the former test. Again, to use another illustration, this hypothesis provides no account for the fact that naming opposites and subtracting 3 when combined into one test gave no shift loss; but when these same activities were used in other combinations, a high shift loss occurred. Even in the case of the calculation tests the shift loss did not decrease consistently with an increase in the difficulty of the separate problem items. It can readily be seen that the concept of a specific time-consuming shift-activity, appearing over and above the activities involved in the tasks between which shift is made, does not lead us far in the analysis of the problem of mental set and shift.

There remains yet another point of view from which to attack the problem. According to this view a sharp line cannot be drawn between the factors that constitute a mental set, and those which constitute shift from an activity which employs one mental set to an activity which employs another. The operation of an apparently uniform and simple mental set involves an element of adjustment in the reponses to successive stimuli. When two or more activities are combined into one performance, a mental set is still operative, and the necessity for adjustment still remains. The adjustments necessary in the uniform activity differ from the shift involved in the more complex activity not so much in kind as in degree. The degree of loss effected by shift in the combined activities will vary with the nature of the responses involved. Let us develop this hypothesis further and consider it in the light of the test results.

That an activity operating under the influence of a fairly simple and uniform mental set involves an element of constant readjustment, or, in other words, an element of shift, is clearly demonstrated by the results from the color naming and form naming tests. It required less time to read through each of the respective blanks five times, naming only one form or color continuously each time, than to read the consecutive items in the order in which they appear. Again, in the case of controlled association, it was pointed out that the factors of overlapping and interference, operative in the separate association lists, indicate that each successive response requires in a measure an adjustment of its own.

In the analysis of the factors that make for efficiency in a shift performance we must, therefore, take into account two significant features: (1) the adjustments required in responding to successive stimuli within a separate and uniform activity, and (2) the adjustments required when two or more separate activities are combined into one performance. Let us designate these respectively as "separate-tasks shift" and "combined-tasks shift." And let us observe the extent to which the efficiency of a shift performance depends upon the degree to which shift is present in the separate tasks as compared with the combined tasks.

It was seen that a noticeable element of separate-tasks shift prevailed in the color naming and form naming tests. The key to this phenomenon was found in the concept of practise. With adult subjects, color naming, for instance, required more time than did the reading of the corresponding printed color names. With children, on the other hand, this difference did not appear. In the case of adults the shift element in the reading of successive words has been reduced to a minimum through practise. As a result the reading of the printed color names proceeds more rapidly than the naming of the colors of the color naming blank. Since the separate color naming and form naming tasks each involved a high amount of shift, the combination of the two tasks into one performance made for only a small amount of shift loss.

The results from the calculation tests likewise pointed to the view that the effects of shift depend largely upon the degree of adjustment required in the shift performance as compared with the facility of the adjustments necessary in the separate tasks. The more practised the mental set for working with simple problems, or, in other words, the more facile the shift from one problem item to the next, the greater would be the relative shift loss in the performance calling for alternation from one type of problem response to another. Stated in other terms, the more practised the separate-tasks shift as compared with the combined-tasks shift, the greater will be the inefficiency of the performance combining the separate activities into one task. In the calculation tests, as well as in the test of color naming and form naming, and in the test of substitution and form naming, the rule appeared that the greater the shift element within the separate tasks, the less will be the shift loss when the separate tasks are combined. In keeping with this finding were the results from the controlled association test and the test of controlled association and calculation. The adjustments required in the separate controlled association tasks fell largely under the categories of overlapping and interference. These factors were similarly operative in the combined-tasks performance. In the case of controlled association and calculation the combined-tasks shift was so highly facilitated by factors inhering in the separate tests that the task combining the two activities actually showed a gain in efficiency.

From all of the tests it was seen that when two activities, each of which employed a distinct mental set, were combined into a single performance, the result was in no way comparable to doubling the difficulty of the task. Apparently a higher and more comprehensive mental set is formed to provide for the more complex performance. This higher mental set not only directs the appropriate response to each distinct type of stimulus but also provides for the shift from one type of response to another. The shift thus effected is not an arbitrary and clearly differentiated factor. It varies with the nature of the activities between which shift is made. If the factors of overlapping and interference are operative in the separate activities, they likewise are operative in the more comprehensive activity. If a considerable shift element prevails in the separate activities, the added shift element in the more comprehensive performance may become almost negligible in comparison. If the shift element in the separate tasks has been reduced to a minimum through practise as compared to the shift entailed when the tasks are combined, the result will be a relatively high loss in efficiency for the more comprehensive mental set. And further, if the stimuli for the combined activities are visibly different, if they are subject to associative aids in the form of different spatial settings, the shift effects in the more compresensive mental set will be appreciably reduced.

Summary

We can restate the outcome of the foregoing analysis briefly as follows: When two or more activities each of which by itself operates with a distinct mental set are combined into one performance, the alternation from one activity to another does not call into play a special shift factor. A more comprehensive mental set is formed, and the shift effects within this mental set differ from the adjustments required in the separate activities not so much in kind as in degree; the more integrated the successive responses in the separate activities have become through practise, the greater will be the retardation effected by shift from one activity to another; the greater the shift effects within the separate activities, the less noticeable will be the added shift involved in combining these activities into one performance; and further, the efficiency of the more comprehensive mental set will be influenced by such factors as overlapping and interference, by the degree to which the discriminability of the stimuli for the separate activities provides a cue to the appropriate response, and as a corollary, by the degree to which the stimuli make for associative interference. In the former case shift is facilitated, in the latter retarded.

In the sections which follow we shall further consider the factors that constitute a mental set and the nature of the ability involved in shifting from one activity to another.

CHAPTER III

Mental Set and Shift as Related to Practise

In the foregoing section we noted the important role played by practise in determining the speed of separate as compared with alternate tasks. It remains for the present section to investigate the influence of continued practise on the two activities.

Significant as is the fact of mental set in all conscious activity, no one would seriously contend that a given mental set is an innate characteristic of the nervous system. It is true that certain prepotent drives, such as those of hunger and sex, predispose an individual to respond to stimuli that will lead to satisfying consummatory reactions. In this sense the prepotent drives with their elaborate physiological substrata constitute mental sets which influence the selection of stimuli and the character of the reactions made to those stimuli. But mental sets of this kind are at best only of a general character. The specific lines of their development within a given individual are to a large measure determined by early training and social influences. Even within the primary reaction tendencies the effects of training, which is another word for practise, can be observed.

What is true for primary behavior patterns is all the more true for the general behavior trends that are acquired. Very few of the associative activities operative in one's daily consciousness have their specific course determined by any innate quality. Consider, for example, the predominating part played by the language function in many of the judgment processes that occupy one's consciousness. Yet language is itself a highly sophisticated reaction system; it is an acquired habit, the result of practise. Further, as a result of practise, that which to the infant is largely an undifferentiated mass of associative material gradually falls into less general categories, and these in turn lend themselves to more specific behavior patterns. And so with training the individual acquires a mental set for this, and a mental set for that. The naming of opposites, the naming of colors, doing mental addition or multiplication, reading a book, or riding a bicycle all employ a characteristic mental set; but this mental set has had its genesis in previous training.

That a mental set makes for economy of effort, that it serves to induce relevant, and exclude irrelevant reactions cannot be doubted. But it does not occupy a dais by right of hereditary predetermination. It is not a separate entity, but an articulated response system. It has come into being through exercise, and it is by continued repetition that it retains its place. The exact limits of a given mental set cannot definitely be defined. The term applies only to reaction patterns showing more or less consistency. It is not an arbitrarily constant system: the set may change somewhat with each successive response; it may become subordinated under a more comprehensive mental set. The outlines of one's response patterns are often at the mercy of minor changes in the internal and external stimulus situation. Take what is known as subjective rhythm as an illustration. Let a metronome beat at a given rate. One subject will observe a two-beat rhythm, another a three-beat rhythm. Gradually also larger rhythm patterns can be detected. But a single accentuated beat of the metronome can change the configuration of the rhythm pattern. Let the subject's attention be distracted for only an instant and a similar change may occur. Subjective rhythm may well be described as a temporary mental set; it illustrates the flexibility with which a mental set can operate.

Carrying our illustration further it can be seen how a given mental set takes form. The Moore theory of consonance and dissonance bears vigorous testimony to the view that individual preferences for musical compositions and even the understanding of musical scores are developed by training. The beginner in music finds difficulty with the simple composition. He has difficulty in articulating the separate elements into a harmonious and pleasing cadence. The materials contain too much of the element of shift. Train the beginner further; his reactions to the various parts of the musical selection have more continuity, function more smoothly. A more comprehensive mental set has been formed. So to a skilled musician a complex selection has unity and conveys a continuous theme. To the uninitiated it is largely a medley of discord: it calls for too much shift from one element to the next, and the higher harmonies are lost in the discrete chords. Practise makes for greater skill in integrating the various parts, and by the formation of more inclusive mental sets the disturbing shift effects are eliminated.

Can we carry this illustration into the field of mental set and shift here investigated? We have already observed that a sharp line cannot be drawn between the shift required in one situation as compared with another. The factors of relative practise in the separate as compared with the alternate tasks, the factors of overlapping and interference, of added interest and incentive induced by the shift element, of shift within each of the separate activities as compared with the shift required when these activities are combined, all play a part in determining the efficiency of a given performance. By the degree to which each or all of these factors are operative, the more complex performance will show much or little shift loss. The present investigation has not studied shift effects as they appear in the illustration borrowed from the field of music: the alternate tasks here employed have been more or less distinct in kind, rather than being more complex forms of the same activity. But even so, in view of the fact that a mental set may have various degrees of comprehensiveness, may operate with only one uniform activity, or may so function as to combine two or more discrete activities into one performance, the above illustration and the present test situations are analogous to a high degree.

In the light of the above observations let us consider the results from the practise experiments. These experiments were arranged to exercise both the separate tasks and the shift performances over an extended number of practise trials. On the assumption that practise is an important factor in determining the apparent shift effects in various situations we should find: First, that the test showing the greatest shift loss will be most influenced by practise in shifting; and, second, that in cases where separate tasks and the shift performance showed little difference in time requirements on the first trial, the practise curves for the two performances will approximate parallel lines.

Each of the tests here reported was employed with a different group of subjects. A total of 108 subjects served in these experiments; 74 of them were students in experimental psychology, and 34 were members of a beginning class in psychology. In all the tests time was the variable measure.

We shall first consider the test of controlled association and calculation. The separate tasks were: (1) name the opposite of each of 25 words; (2) subtract 3 from each of 25 two-place numbers. The shift task called for alternation between the same number of association and calculation stimuli.

In an earlier section we have described the method used in providing four arrangements of the test material used in this test and in the three that follow. The necessity of this procedure can readily be seen. All of the tests used presented quite elementary stimulus situations: to make a judgment of the kind required in simply naming a color or a form, naming an opposite, subtracting 3, or substituting a number for a form, involves only a simple response pattern. Simple situations of this kind were deliberately chosen, but it was particularly important to retain the distinctive character of the tests throughout the entire practise period. To have presented only one arrangement of the material would have permitted the subject to memorize the stimulus items in the order in which they appeared. With the precaution against memorization, each stimulus would continue to call for a distinctive

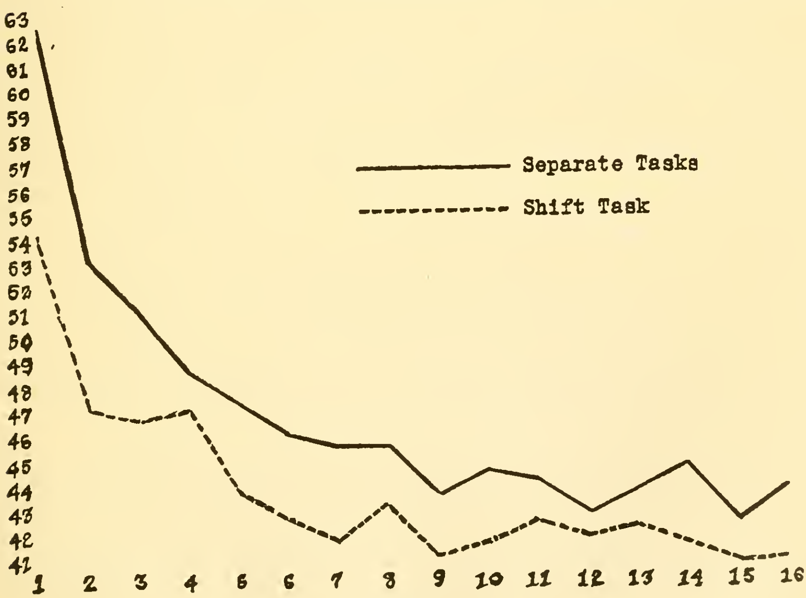

FIGURE 1.

Improvement in Naming Opposites and Subtracting 3. The abscissas give the number of practise trials; the ordinates the average time in seconds for each trial.

response, and the experimental factors under investigation, shift and the absence of shift, could be directly studied. The interpolation of three different arrangements of the test material between each repetition of a previous arrangement was considered sufficient to rule out the effects of memory, especially since the shortest test contained 50 items, while the other three each contained 100 items.

The test of association and calculation was given to eighteen subjects, each of whom completed 16 trials. The practise curves, presenting the averages for each trial, appear in Figure 1.

The shift performance is in the lead through the entire practise period. Both curves show the typical practise contours. After the third trial the two curves approach each other and from this point follow approximately parallel lines. The fluctuations that appear are minor and not of further significance. We postpone further discussion to take up the results from the other tests.

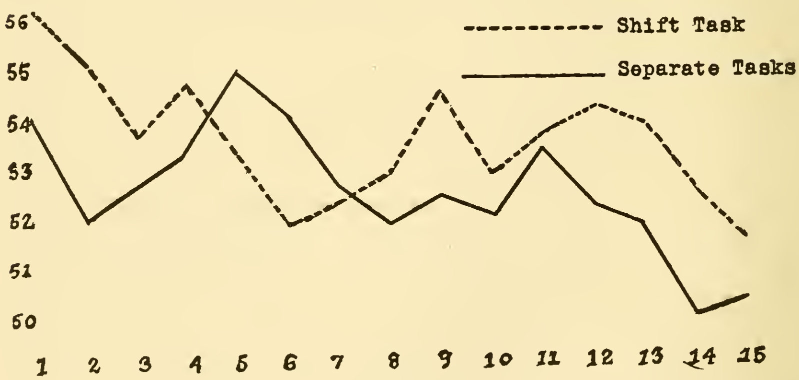

FIGURE 2.

Improvement in Form Naming and Color Naming. The abscissas give the number of practise trials; the ordinates the average time in seconds for each trial.

The color naming and form naming test contained, for the separate tasks, 50 color stimuli, and 50 forms, and for the shift test the same number of items arranged for alternation between colors and forms. Sixteen subjects completed 15 trials of the test. The practise curves appear in Figure 2.

From the curves in Figure 2 it will be seen that the shift performance is slightly at a loss throughout the practise period, with exception of the sixth trial. Neither performance shows marked improvement. Both curves show a good deal of fluctuation. This is in part explained by the fact that a smaller number of subjects was used in this experiment than in any of the others, in part by the fact that the tests show less improvement. The last trial shows a decided end spurt.

It remains to account for the fact that the two curves do not tend to converge as the practise period proceeds. In a previous section it was seen that the separate color and form naming activities contain in themselves a marked degree of shift. The shift effect in the separate tasks is relatively as great as the added shift entailed by combining the two tasks into one performance. The results here accord with the principle that, where a condition of this kind obtains, the practise effects for the shift task should be similar to the effect of

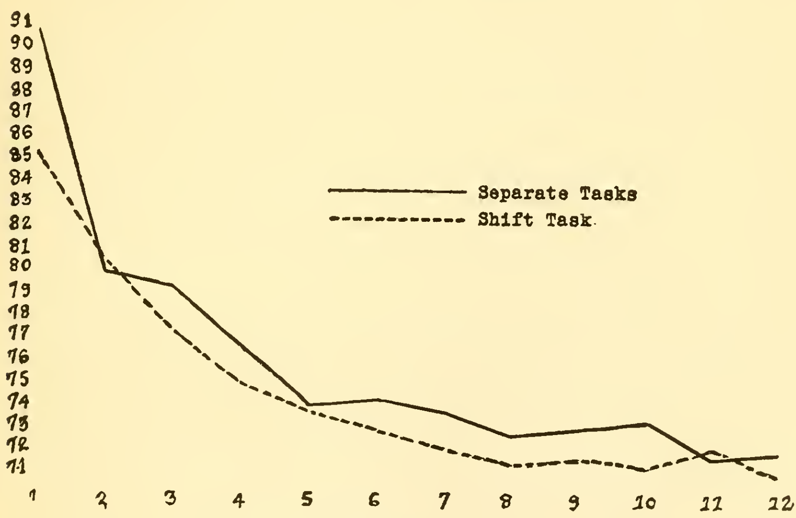

FIGURE 3.

Improvement in Test combining Color Naming, Form Naming, Naming Opposites, and Subtracting 3. The abscissas give the number of practise trials; the ordinates the average time in seconds for each trial.

practise on the separate tasks. It can be seen from the curves that neither performance shows any marked improvement through practise as compared with the other.

We come next to the test combining the four processes of color and form naming, naming opposites, and subtracting 3.

The separate tasks of this test consisted of 25 items of each type of stimulus, and the shift test combined all of these into a performance calling for shift between the four types of response. Eighteen subjects completed 12 trials of this test. The results appear in Figure 3.

With this test we again meet a situation where shift does not effect a loss. The two curves show the typical practise contours. The high initial gain for shift is due to the fact that the Shift Last procedure was used. But after discounting the results from the first trial, it appears that the two curves run almost side by side, with minor fluctuations. It is especially significant that the shift performance should retain its position throughout the practise period. If it is supposed that the harmful effects of shift are partly clouded by an added display of energy on the part of the subject, the results from the various practise experiments should bear out this supposition. In an extended practise period two opposing tendencies are at work. One is the improvement that follows from the practise effects of previous repetitions. The other is the cumulative effect of fatigue and monotony that comes with continued exercise of the same function. If the shift test requires a greater amount of effort than do the separate tasks, it should suffer more from the effects of fatigue, since increased fatigue should make for diminished ability to exert effort. A glance at the curves will show that the shift performance holds its own until the end.

The result has an important bearing upon considerations that have already been made. It shows that a comprehensive mental set can integrate the elements of four separate activities and still function with a high degree of success. And it shows that the efficiency of the shift performance arises from factors that inhere in the situation itself and not from an increase in effort on the part of the subject.

We pass on to the form naming and substitution test. The separate tasks in this case consisted of 50 forms that were to be named, and 50 forms for each of which an appropriate number, as designated by an accompanying key, was to be substituted. The shift test called for alternation between form naming and substitution. Of the tests so far considered, this one showed the most conspicuous shift effects. Since the same stimulus item required now the naming of a form, now the naming of a number, the test gave opportunity for associative interference as well as shift. In designing four arrangements of the test material, this factor of interference could not be kept constant from one trial to the next. In one trial the subject was required to name the forms of the first half of the blank, substitute a number for each form in the second half; on the next trial the substitution task preceded that of form naming. This condition obtained in the tests of

FIGURE 4.

Improvement in Form Naming and Substitution. The abscissas give the number of practise trials; the ordinates the average time in seconds for each trial.

the separate tasks. Similarly in the shift test: in the first trial, the first item was a stimulus for form naming; the second for substitution; on the second trial, the responses came in the reverse order. The effect of practise on both shift and associative interference can be seen from the curves in Figure 4. Twenty-two subjects completed 10 trials of the test.

From Figure 4 it can be seen that the shift performance is decidedly at a loss throughout the entire practise period. Both curves show the effects of associative interference in the first eight of the ten trials. The even numbered trials (2, 4, 6, 8) show either a higher time score or a retardation of improvement as compared with the odd trials. In the test of the separate tasks, the substitution test preceded the form naming test on each even numbered trial. The effect of responding first to the substitution test is more detrimental to the subsequent form responses than when the reverse procedure is followed. Similarly in the shift test: to alternate in the order, name form, then substitute, proceeded more speedily than the reverse order. This result can perhaps be accounted for by the fact that at the beginning of the practise performance substitution is decidedly more difficult than form naming. It involves not only the naming response required in form naming but also the added feature of remembering the appropriate number that is to be substituted for each form. Because of its greater difficulty it requires more careful attention and closer application. The mental set which it employs is more absorbing and consequently more persistent in its tendency to perseverate after the necessary responses have been made. In this sense we have here an illustration of the perseveration phenomenon studied by Lankes. As the experiment proceeds, the evidences of perseveration gradually disappear, and at the end of the practise period there is no significant difference between the odd and even numbered trials.

Of more significance is the general outline of the two respective curves. The improvement in shift is decidedly greater than that in the separate tasks. The shift curve strikes a high point at 101.8 seconds on the second trial, and falls to a low point of 88 seconds on the ninth. The curve for the separate tasks has its high point at 82 and its low point at 76. There is an improvement of 13.8 seconds in the former as compared with 6 seconds in the latter. Both relatively and absolutely this makes for greater improvement in the shift performance. The shift curve shows a noticeable tendency to move closer and closer to the level of the curve for the separate tasks. Only a further continuation of the experiment could decide whether the two curves will eventually coincide. But it can be seen that even toward the end of an arduous practise period, the shift curve is still on the decline in spite of whatever fatigue the previous exercise may have induced.

The effect of practise on shift is even more strikingly demonstrated in a test of controlled association of which only two trials were given. The separate tasks in this test consisted in the naming of an opposite for each of twenty words, and the naming of an object for each of twenty verbs. The shift test made use of a similar number of equivalent stimulus words arranged for alternation between naming an opposite and naming a verb-object. On the second trial the stimulus items used for the first trial of separate tasks were presented in shift arrangement, and the previous shift stimuli were presented in separate lists. In this way the second trial made use of the same material as the first, but the materials of the foregoing test of separate tasks and shift were interchanged. The tests were given individually by the experimenter to 34 Barnard freshmen. Time was taken with a stop watch. The group was divided equally between the Shift First and Shift Last procedures. The results from the group as a whole appear in TABLE X. Median scores, with Q as the measure of variability, are given.

TABLE X

Naming Opposites and Verb-Objects. Shift First and Last Combined

	Trial 1	*Trial 2*
S. T.	50.5 (5)	48 (5.5)
Shift	63 (8)	51 (7)
% Loss	25 (9.5)	4 (8.5)

The results presented in TABLE X show that a previous practise trial reduces the score in separate tasks from 50.5 to 48 seconds, or a gain of 2.5 seconds. The corresponding figures for the shift performance are 63 and 51, or a gain of 12 seconds. Taking both relative and absolute gain into account, the shift performance shows outstanding improvement on the second trial. This feature is even more clearly demonstrated by the per cent loss scores. The per cent loss scores were obtained by finding for each individual the percentage of increase in time required in doing the shift task above that required for the separate tasks. This score falls from 25 to 4 after one practise trial. (The high variability of the latter score is due to the fact that some subjects showed a gain, others a loss in doing the shift test.) The improvement demonstrated by this sharp decline in per cent loss is quite out of proportion to the gain wrought by practise as shown by the absolute scores. It demonstrates all the more strongly the marked effect which practise has on a shift performance.

Summary

The foregoing results show: (1) That where there are pronounced initial shift effects, the effect of practise is to cause greater improvement in the shift performance than in the separate tasks; (2) that where there is no shift loss, the curves for the separate tasks and shift performance follow approximately parallel lines; (3) that the shift performance is not more fatiguing than the separate tasks.

The evidence indicates that just as a given mental set comes into being through practise so also a more comprehensive mental set, calling for shift between activities which taken separately involve mental sets of their own, can be formed through practise. After more or less practise, depending upon the activities involved, this more comprehensive set will function just as efficiently as the mental sets of a more simple character.

CHAPTER IV

Mental Set and Shift as Related to Intelligence

Intelligence, according to one definition, is a "general capacity of an individual consciously to adjust his thinking to new requirements: it is general mental adaptability to new problems and conditions of life."[17] This definition lays particular stress upon the factor of adaptability. A definition by Burt carries the same emphasis when he states that his studies "strongly suggest that it is one feature or function of attentive consciousness which forms the basis of intelligence, namely, the power of readjustment to relatively novel situations by organizing new psychophysical coordination."[18] According to these definitions the person of highest intelligence should, on the whole, be most capable of performing the shift operations studied in the present investigation.

The measures of general intelligence obtained for the various groups that served as subjects in this experiment were as follows: The school children were given the Otis Self-Administering, Intermediate Examination, Form A; a thirty-minute period was used. A group of adult university students were given the Army Alpha, Form 8, according to the directions provided by Yerkes and Yoakum, and the Otis Self-Administering, Higher Examination, Form B; in this case a twenty-minute period was used. For the Barnard subjects the scores in the Thorndike general intelligence test were used.

Two measures of the relation between intelligence and ability to shift are obtainable from the results of the tests employed in this experiment. First, since each test gave a score for separate tasks and a score for shift, each of these can be correlated with intelligence scores and the results compared. Second, the individual scores in per cent loss, derived from finding the difference between the separate task and the shift score for each individual in each test and expressing this difference in terms of a percentage, can also be correlated with intelligence scores. In the first case, if shift cor-

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[17] W. Stern, *The Psychological Methods of Testing Intelligence,* Trs. by G. M. Whipple, Educ. Psych. Monog. No. 13, 1914, p. 3.

[18] Brit. Jour. Psych. III, 1909-1910, pp. 94-177.

relates positively with intelligence, the coefficient of correlation between intelligence scores and shift scores should be higher than the coefficients obtained from correlating intelligence and scores in the separate tasks. Further, the tests showing the most conspicuous shift loss should show a higher relative correlation with intelligence than those in which shift effects were not so pronounced. The second measure makes use not of absolute scores but of the ratio derived from them. Although this measure overlaps to a large degree with the measures described in the first case above, it arrives at the relationship from a different approach. Take an example: Individuals A and B rank 1 and 2 respectively in intelligence. A makes a score of 20 seconds in the separate tasks, and a score of 30 in shift; B makes corresponding scores of 30 and 36. If we were to correlate these scores with intelligence the coefficient in each case would be +1.00. But now take the "per cent loss" scores: A's per cent loss is 50, *i.e.*, it required 50 per cent more time to complete the shift task than to complete the separate tasks; B's per cent loss score is 20. In this case, by giving the higher rank to the lowest per cent loss score, the correlation between intelligence and shift would be —1.00. From this illustration it can be seen that in a given group the correlation between intelligence and scores in separate tasks and shift could both be extremely high or low while the correlation between intelligence and per cent loss showed just the reverse results. It can further be seen from this that even a very low positive correlation in the latter case would be significant. In the former case we might well expect a positive relationship between scores in intelligence tests and scores in the present tests. But in the latter case the measure of ability to shift is taken apart from the actual rankings of the absolute scores, and as such we have a means of arriving at a distinct index to the relation between intelligence and shift.

The tables which follow present the findings from the various tests. The Rank Difference correlation method was used throughout. In parenthesis is given the probable error of each coefficient. The formula used to obtain this measure was $\text{P.E.} = \frac{.7063 \times (1 - r^2)}{\sqrt{n}}$. In the preceding section it was observed that two procedures, Shift First, and Shift Last, were used. Since the use of two procedures has the effect of dividing the groups and thereby reducing the number of scores available for each separate correlation, the results from both procedures were in some cases combined in the present instance. In order to combine the scores it was necessary to weight them to make the results from the two procedures comparable. The method used in combining scores was to weight them according to the variability of the test results.

We shall first consider the results from the calculation tests. TABLE XI gives the coefficients obtained from the four problem situations presented to the groups of Barnard students. The Thorndike general intelligence scores were used as measures of intelligence. The number of cases is 44. The captions S. T., Shift, and % Loss designate respectively the three measures obtained in each test.

TABLE XI

	Add-Multiply	*+6—3*	*+14—7*	*+17—13*
S. T.	.20 (.11)	.35 (.10)	.42 (.09)	.38 (.09)
Shift	.30 (.10)	.43 (.09)	.44 (.09)	.41 (.09)
% Loss	.24 (.11)	.20 (.11)	.19 (.11)	.17 (.11)

From TABLE XI it appears that even though all the correlations are quite low, due largely to the fact that the students who served in this experiment were on the whole a select group and therefore would not show as wide an intelligence range as individuals chosen at random, yet the correlation between shift and intelligence is consistently higher than that between intelligence and separate tasks. There is a consistent positive correlation also between per cent loss and intelligence. It should be remembered that the per cent loss rankings were made to give the highest rank to the individual who showed the lowest shift loss. It is significant that the test which showed the most conspicuous effects of shift—namely, the first one—also shows the most pronounced correlation between shift and intelligence.

TABLE XII gives the results obtained from groups of school children, one group of whom performed the test of adding and multiplying, and adding 6 and subtracting 3 by the Shift Last procedure, and the other the latter test according to the Shift First procedure. Each of the three entries represents the results from 40 cases. The measure of intelligence in this case was the Otis Intermediate Examination.

TABLE XII

	Add-Multiply	*+6—3*	*+6—3*
S. T.	.39 (.10)	.50 (.08)	.46 (.09)
Shift	.52 (.07)	.42 (.09)	.44 (.09)
% Loss	.15 (.11)	.01 (.12)	.09 (.12)

In the table above the test showing the highest shift loss, namely the "Add-Multiply" test, also shows the highest correlation between intelligence and the measure of shift. The two entries for the "Add 6-Subtract 3" performance do not give reliable positive evidence of a relationship between the type of ability required in shift and the type of ability that makes for high performance in intelligence tests.

TABLE XIII gives the results from a group of 30 adults who were given both the Army Alpha and the Otis Higher Examination. The number of cases is small, but the results are presented to show the consistency with which the main findings appear.

TABLE XIII

	Add-Multiply	*+6—3*	*+14—7*
	Army Alpha		
S. T.	.39 (.11)	.67 (.08)	.62 (.08)
Shift	.56 (.09)	.51 (.09)	.58 (.08)
% Loss	.47 (.10)	.17 (.13)	.33 (.12)
	Otis Higher		
S. T.	.25 (.13)	.44 (.10)	.52 (.09)
Shift	.46 (.10)	.33 (.12)	.46 (.10)
% Loss	.38 (.11)	.01 (.13)	.06 (.13)

The coefficients obtained by correlation of test scores with scores in the Otis intelligence test are consistently lower than the corresponding figures for the Army Alpha correlations. This may explain in part the low correlations presented in TABLE XII. It will be observed, however, that the correlation between intelligence and per cent loss is positive in all cases with the group represented in TABLE XIII, and that the test showing the highest shift loss also shows the highest correlation between the measures of shift and intelligence. This same finding appears in the table which follows; it gives the figures obtained from correlating scores in the test calling for the addition of 1 and the subtraction of 1 from the columns of numbers used in the test situations presented above. In this case there are 22 subjects with the Thorndike test as the measure of intelligence.

TABLE XIV

S. T.	.25 (.13)	Shift	.57 (.10)	% Loss	.29 (.13)

We can now summarize the findings for the calculation tests. In all cases there was a positive correlation between intelligence and per cent loss, this correlation being higher for the tests which showed the most conspicuous effects of shift. The consistency of this result is of some significance over and above the actual statistical reliability of the figures presented. There were no duplications of groups in the tables presented above.

The results from other tests will next be considered. First among these is the test combining the naming of opposites and verb-objects. TABLE XV gives the results from the 34 subjects who served in this experiment. The measure of intelligence was the Thorndike test.

TABLE XV

S. T.	.34 (.11)	Shift	.52 (.09)	% Loss	.46 (.10)

Here again there is evidence of a relationship between ability to shift and general intelligence. The evidence in this case is as pronounced as that of the calculation tests showing the highest shift loss. Further results are presented in TABLE XVI which gives the coefficients obtained from correlating the scores of 22 subjects in the test calling for counting by 2's and 3's with Thorndike scores. In this case, instead of finding the per cent loss score a corresponding measure was derived by finding the ratio which the shift score bore to the score in the separate tasks.

TABLE XVI

S. T.	.27 (.15)	Shift	.29 (.14)	Shift Ratio	.10 (.15)

The results do not show high reliability, but it is interesting to observe that the correlation between intelligence and shift remains consistently positive. The same finding appears in the table which follows. It presents the results from the practise experiments calling for shift between form naming and substitution, color naming and form naming, naming opposites and subtracting 3. Thorndike intelligence scores were used in these correlations.

TABLE XVII

	Form Naming and Subst.	*Color-Form*	*Opposites —3*
S. T.	.75 (.08)	.29 (.16)	.40 (.14)
Shift	.80 (.07)	.31 (.15)	.42 (.14)
% Loss	.39 (.14)	.32 (.15)	—.06 (.16)

It was seen in a previous section that the test of form naming and substitution showed a conspicuous shift loss; the color naming and form naming test showed less shift loss; and the test of naming opposites and subtracting 3 gave a gain for shift. From the results in TABLE XVII it can be seen that form naming and substitution presents the highest correlation between per cent loss and intelligence; next in order comes color naming and form naming; and then follows the test of naming opposites and subtracting 3 which shows a negative correlation. This negative coefficient is low and unreliable; but the fact that it is negative is not inconsistent with the findings that have appeared in connection with other tests: the "per cent loss" in the case of this test is actually an average gain for shift, and consequently the correlation is positive in the direction of per cent loss for the separate tasks.

In summarizing the results that have appeared in this section, it is necessary to proceed with caution. In a prolonged practise experiment, or in a study of the comparison of shift loss in one test with shift loss in another, conclusions can be drawn with a higher degree of certainty from a given number of cases than when the same number of cases are used for purposes of correlation. However, in the present section are presented the results from ten different groups of subjects measured in ten different tests, and four independent intelligence measures have been employed. The consistency with which the main findings appear under this wide range of conditions strengthens the conclusions that can be drawn.

It is apparent first of all that ability to adjust to a new situation, such as that presented in the shift performance as compared with the separate tasks and measured in terms of the percentage of loss entailed by shift, shows a consistent positive correlation with performance in intelligence tests. This result is all the more conspicuous in the tests which showed the highest amount of shift loss. On the whole, the correlation between intelligence scores and scores in the shift performance, regardless of per cent loss, was higher than the correlation between intelligence scores and scores in the separate tasks.

In all cases there is a relatively high correlation between the measure of intelligence and the scores, both in the separate tasks and in the shift performance. The tests used in the present experiments all have points in common with the standard tests of intelligence. In all of them the factors of speed of perception, speed of association, speed of adaptability are called into play. These factors also enter into the tests of intelligence. Furthermore, the intelligence tests present original problems and call for rapid adjustments to novel situations. The same holds true in large measure for the shift tests used in the present experiments. Consequently, rather than say that the intelligent individual succeeds better in the shift task *because* of his high intelligence we should say that he succeeds, both in the test of intelligence and in the shift test, because the two situations call into play reactions that are identical to a high degree. Both forms of test measure elements that go into what we may call general ability, or general intelligence. That the standard intelligence tests constitute a more comprehensive index to this general ability than do the tests of shift used in the present experiments cannot well be denied. But it would be equally unjustifiable to conclude that the positive correlations between intelligence scores and scores in shift indicate a special talent that can be regarded apart from the general quality of an individual's mental endowments. Before proceeding further with this suggestion it will be profitable to take into account the findings which appear in the section which follows.

CHAPTER V

Shift as Related to General Ability

In the foregoing sections we have considered in turn shift effects as related to the type of task, the role of practise in shift, and the relation of the factors involved in shift to the factors that make for general intelligence. On the first point we noted that shift effects vary greatly under different conditions, that in some combinations of task shift makes for a high loss in efficiency, that in others its effects are almost negligible, while in some cases it actually makes for increased speed of performance. On the second point it appeared that practise plays an important part in determining shift effects, that shift loss is largely determined by a difference in automaticity of the separate tasks as compared with the novel shift situation, and that the effect of practise is to reduce both performances to a common level. On the score of the relation of factors that make for ability to shift to factors that make for general intelligence, it was seen that the more intelligent person, as measured by intelligence tests, not only obtained a better score in the shift performance but also suffered the least relative loss in passing from the separate task performances to the performance calling for alternation between elements of the separate tasks.

In the analysis of the factors that enter into the shift operation a very important feature remains to be considered. Early in the present study we were led to the view that every mental task involves not only a factor which we designate 'mental set' but also entails an element of adjustment to the successive constituent parts of an apparently uniform activity. No arbitrary dichotomy can be made between mental set and mental shift in any given situation. A mental set may operate in a uniform activity, inducing appropriate preparatory reactions and entering into the stimulus situation to elicit responses of a uniform character. But even the most elementary uniform activity calls for adjustment; it is in a sense a test of adaptability, and to this degree also a test of shift. Likewise, in passing from a task involving a uniform mental set to one which combines two or more distinct activities into one performance, the fact of mental set is still present, while the element of shift is increased. This increased shift is not, however, necessarily of a species of its own. Like all other response patterns it is subject to the influence of practise, of such factors as overlapping and interference, dynamogenesis, added interest and incentive, and its manifestations in a given combination of tasks are largely determined by the degree of shift present in the separate tasks taken by themselves. From this consideration we are led to a significant query: To what extent is performance in the shift task a function of the type of ability required by the separate activities between which shift is made? This query leads further into the general problem of the relation of ability to shift to general ability, and it should enable us to make pertinent observations on the problem as to what constitutes mental set and shift.

The present approach differs from that of previous investigators in the field. In the historical survey it was seen that various investigators had studied factors which had much in common with the shift factor here in question. Lankes, it was seen, found evidence of a general tendency which he called the 'perseveration factor.' As related to the present study, a high degree of perseveration would make for low ability in shift. The results of Woodrow's study on the faculty of attention were in harmony with those of Lankes. McQueen, on the other hand, did not find evidence of a general capacity for distributing the attention. None of these investigators took full account of the relation between the particular factor studied and the type of ability which made for skill in doing the performances which served to give control data in the experiments. It is on this problem that the present study will center its main attack. Incidentally we shall consider whatever evidence there may be of a special shift factor. This factor, if it can be found, must stand out over and above the type of general ability required in doing the various performances that were tested. On this point we can also consider whether a factor such as this must be regarded as a unique attribute of mental activity or whether it is an integral part of more general capacities.

Three scores obtained in each test will be used in the present investigation: (1) The score in the separate tasks, (2) the shift task score, (3) the score in percentage of loss or gain which the latter measure bears to the former. This third measure, it should be observed, falls in a category by itself.

To illustrate: A made a score of 20 seconds in a test of the separate tasks, and a score of 30 seconds in shift. The latter score is 50 per cent higher than the former, and consequently we designate his "per cent loss" score as 50. B made corresponding scores of 30 and 42 seconds in the two tests. His per cent loss score is 40. Now, let us suppose that A and B made similar scores in a second test. If we correlate the per cent loss scores of the two tests we have a coefficient of + 1.00 : B made the better showing in per cent loss scores in both tests. Given a large number of cases for which this finding would hold true, we might conclude that there is a special shift factor characterizing an individual in all situations, and then let the matter rest with that. But to proceed in this manner would be to do violence to another significant feature; namely, that if we take the actual scores, rather than per cent loss scores, the individual who ranks highest in the separate tasks also ranks highest in the shift performance. The former investigators operated with the former procedure to the exclusion of the latter. Yet it can be seen that, even though it is of interest to find that individuals lose relatively the same percentage in going from one shift situation to another, it is still more important to observe that the efficient performer in the separate tasks also stands highest in the shift performance.

In the tables which follow the results will be presented in accordance with the general plan suggested above. The correlation of scores in separate tasks and shift within the same test, of scores in separate tasks in one test with corresponding scores in others, and of scores in the shift test of one each experiment with corresponding scores in others will be given. After each table will follow the figures giving the correlation of per cent loss scores in the various tests. The coefficients were all obtained by the Rank Difference correlation method.

TABLE XVIII gives the results from 33 subjects who followed the Shift First procedure in doing the four calculation

TABLE XVIII

	Add-Multiply	*+6—3*	*+14—7*	*+17—13*
Add-Multiply	(.76)	.74	.72	.68
+6—3	.53	(.76)	.80	.73
+14—7	.62	.78	(.74)	.71
+17—14	.60	.84	.90	(.84)

tests. The *plain* type gives the coefficients obtained in correlating the separate tasks scores of the various tests. The **bold** type gives the correlation between scores in shift tasks. In parentheses are given the coefficients obtained in correlating scores in *separate tasks* with *shift* scores within the *same* test.

The intercorrelation of per cent loss scores gave the following coefficients: between the first problem situation and each of the following, in order: .10, .08, .07; between the second and third, .33; between the second and fourth, .50; between the third and fourth, .18. The average of these intercorrelations is .21. By weighting the per cent loss scores and combining them by the method of combining test scores according to variability, the correlation between per cent loss in the first two and last two problem situations gave a coefficient of .45. It can be seen that the coefficient is raised considerably by the combining of results from two tests. The same procedure gave a correlation of .79 between separate tasks and shift tasks in the first two tests, and of .91 in the second two.

TABLE XIX gives the results obtained from a group of 36 subjects who followed the Shift Last procedure with the four calculation tests.

TABLE XIX

	Add-Multiply	*+6—3*	*+14—7*	*+17—13*
Add-Multiply	(.62)	.63	.68	.67
+6—3	**.64**	(.67)	.75	.78
+14—7	**.66**	**.76**	(.80)	.83
+17—13	**.63**	**.78**	**.83**	(.84)

The intercorrelation of per cent loss scores gave the following coefficients: between the first problem situation and each of the following three, in order: .25, .02, .26; between the second and third, .37; between the second and fourth, .30; between the third and fourth, .19.

The average of these per cent loss intercorrelations is .23. By combining scores as above, the correlation between per cent loss in the first two and last two problem situations gives a coefficient of .45 in this case also. The same procedure applied to the scores in separate tasks and shift gives for the first two problem situations a correlation of .79, and for the last two, .83.

By taking the averages of the figures presented in the above tables we find the following: Intercorrelation of scores in separate tasks, .75 and .72; intercorrelation of shift scores, .72 and .71; correlation of scores in separate tasks and shift within each test, .74 and .77; intercorrelation of per cent loss scores, .23 and .21. It will be seen from this that the correlation between ability in separate tasks and shift within the same test is somewhat higher than the intercorrelation of abilities in the various tests employed. In like manner it is seen that ability in a shift task is decidedly more closely a function of the ability that makes for efficiency in the separate tasks between which shift is made than of any special shift factor which the per cent loss coefficients should reveal.

That there should be a positive correlation between performance in the separate tasks and in the shift tasks is to be expected since both tests contain common elements. But on the assumption that there exists a special shift factor, we should also expect the results to take a somewhat different turn than they do. Take as an illustration the first two problem situations presented in the tables above. The Add-Multiply problems gave for the two groups represented in TABLES XIX and XVIII a median per cent loss of 54 (see TABLE II). In other words, although operating with stimulus items similar in kind and equal in number, the shift task required a median 54 per cent more time for completion than did the separate tasks. The added shift element required a time expenditure equivalent to more than one half the amount of time expended in doing the separate tasks. This proportion is very high and should give ample opportunity for a special shift factor to express itself if such a factor is actually to be found. The per cent loss in the second problem situation was 34, again a high figure. But when we come to correlate the independent measures of shift ability, the per cent loss scores, we find coefficients of .10 and .25 for the two groups in question. When we correlate the measures of ability in the separate tasks and in the shift task the problem situation showing the highest shift loss gives coefficients for the two groups of .76 and .62. The corresponding coefficients for the second problem situation are .76 and .67. It is not surprising that the per cent loss coefficients should be lower than those obtained by correlating scores in separate tasks and shift within the same test. It was seen in connection with each of the tables presented above that to combine the per cent loss scores of various tests raises the correlations considerably. But in view of the high shift loss demonstrated by the two tests here in question, and on the assumption that there is a special ability to shift apart from general ability, it is especially significant to observe the marked discrepancy between the coefficients obtained from the two correlation procedures.

The following considerations follow from the findings presented above: (1) There is evidence of shift-ability appearing over and above ability in the performance tested, as evidenced by the positive correlation between per cent loss scores in the various tests; and (2) there is stronger evidence to show that this ability to shift does not operate independently in the shift performance, but that the type of ability that makes for high performance in a relatively uniform activity also makes for high performance in activities that involve more shift. Let us see how this generalization fares in the light of the findings which follow.

Table XX gives the results obtained from two groups of school children, the first group containing 40 and the second 39 subjects. Both groups were given the Add-Multiply test according to the Shift Last procedure; the first group followed the Shift Last and the second the Shift First procedure in the test of Add 6-Subtract 3. Again the correlations between separate task scores are given in plain type, between shift scores in bold type, between separate task and shift within the same test in parentheses.

TABLE XX

	Add-Multiply	*+6—3*	*Add-Multiply*	*+6—3*
Add-Multiply	(.92)	.78	(.76)	.90
+6—3	**.78**	(.80)	**.76**	(.87)

For the first group represented in TABLE XX the correlation between per cent loss scores in the two tests was .27; for the second, .00. It will be observed that in this case again the correlations between ability in the uniform activities of the separate tasks and the shift performance are very high.

In the table which follows the results from a group of 30 adults who completed a test of controlled association, calling for the naming of opposites and verb-objects, a cancellation test, and three tests of calculation are presented.

TABLE XXI

	Add-Multiply	*+6—3*	*+14—7*	*Assoc.*	*Cancell.*
Add-Multiply	(.56)	.64	.81	.63	.67
+6—3	**.80**	(.84)	.83	.70	.59
+14—7	**.89**	**.86**	(.80)	.75	.54
Assoc.	**.79**	**.75**	**.73**	(.64)	.63
Cancell.	**.76**	.58	**.71**	**.77**	(.83)

The following coefficients were obtained in correlating the per cent loss measures for the tests represented in the above table: calculation tests, .36, .61, .32; calculation tests combined and association, —.10; calculation tests combined and cancellation, —.14; cancellation and association, .18. In this case the association tests were given in writing and adjacent lists were used in the shift test; the result was that practically no shift loss effects were demonstrated, some subjects showing a gain, others a loss. The cancellation test showed very little shift loss either. For this reason the negative per cent loss correlations are not so significant as they would be had there been more marked shift effects. The intercorrelation of per cent loss scores in the three calculation tests gives relatively high positive coefficients in this instance as in the previous cases. The correlations between separate tasks and shift tasks within the same test are consistently high.

A group of 33 subjects were given the three tests Add 1-Subtract 1, Counting by 2's and 3's, and Naming Opposites and Verb-Objects. The two first named tests showed very marked shift effects, and the activities involved in the various tests are quite dissimilar. For this reason the results are of particular interest in this connection. The findings appear in TABLE XXII.

TABLE XXII

	+1—1	*Count by 2's and 3's*	*Assoc.*
+1—1	(.56)	.53	.29
2's and 3's	**.42**	(.57)	.26
Assoc.	**.33**	**.22**	(.80)

The correlations between per cent loss scores are: Add 1-Subtract 1 and Counting by 2's and 3's, .29; Naming Opposites and Verb-Objects, .18; Counting by 2's and 3's and Naming Opposites and Verb-Objects, .21. It will be seen that the per cent loss correlations are relatively quite high as compared to the intercorrelations of abilities in separate tasks and shift performance of the various tests. It is apparent in this instance too, however, that the correlation between ability in separate tasks and shift within the same test is higher in each case than any other correlations obtained.

We pass now to the results from the tests used in the practise experiment. The subjects who served in these experiments number 74 and are distributed as follows: form naming and substitution, 22; association and calculation, 18; color naming and form naming, 16; color naming, form naming, naming opposites and subtracting 3, 18. By employing for each test the scores in the first half and the second half of the practise period, the correlation between per cent loss scores for the same test could be found. For the four tests the correlations between per cent loss in the first half and second half of the practise period are as follows: Form Naming and Substitution, .47; Color Naming and Form Naming, .72; Naming Opposites and Subtracting 3, .69; Color Naming, Form Naming, Naming Opposites, Subtracting 3, .69. For the same tests the correlations between scores in separate tasks and shift over the entire practise period are respectively as follows: .85, .77, .87, .97. It will be seen that the latter coefficients again show that a high relationship exists between ability in the uniform separate activities and in the shift performance.

The subjects who served in the practise experiments also completed the four calculation tests, the results from which appear in TABLES XVIII and XIX. Further evidence as to the existence of a separate shift factor can therefore be obtained by correlating per cent loss scores in the two test series. By combining per cent loss scores of the first two and last two calculation tests and employing the corresponding scores obtained in the first and second half of the practise experiment, four coefficients were obtained in each case. The average of these for the four situations are as follows: Form Naming and Substitution and Calculation, .43; Color Naming and Form Naming and Calculation, .06; Naming Opposites and Subtracting 3 and Calculation, .47; Color Naming, Form Naming, Naming Opposites, Subtracting 3 and Calculation, —.10. The correlation of per cent loss scores is positive in three of the four situations.

In summarizing the results presented in this section we find the following: The results from eleven different tests have been presented. Not counting the cases in which different groups duplicated the same tests, and counting out the results obtained from correlating scores within the same test, as in the case of the practise experiments, a total of sixteen per cent loss correlation coefficients is given. Of these 13 are positive, ranging from .06 to .52, and 3 are negative, ranging from —.10 to —.14. The negative correlations were obtained from tests which did not show conspicuous shift effects; namely the test of cancellation, written association, and the test combining color naming, form naming, naming opposites, and subtracting 3. In view of this the negative correlations cannot be regarded as contradictory of the results from tests which showed marked effects of shift. On the whole the evidence tends to show that the individual who suffers a high amount of loss in going from the separate tasks to the shift performance in one test situation will also suffer a relatively high loss in another situation. Because of the low correlations this principle can be applied only in a general way, but it has significant implications in view of the findings made by other experimenters.

It was pointed out that the measures of perseveration employed by Lankes, for instance, correspond to a large degree to the per cent loss measure used in the present experiment. It was on the basis of positive correlations analogous to those presented above that this investigator arrived at the concept of a perseveration factor appearing over and above general ability. By the same token we might in the present case see evidence for a concept of a special shift-ability, characteristically different for different individuals. The investigation and analysis of a special factor such as that involved in this assumption would constitute a separate study in itself. For the purposes of the present study we shall consider the problem of shift in its more general aspects.

In all cases it was seen from the foregoing tables that the most significant determinant of ability in a shift performance was ability in the separate tasks which went into this performance. The correlation between the two measures range from .56 to .97; the median of the 24 coefficients presented is .80, with a Q of .085. For all practical purposes the key to an individual's competence in a task involving shift must be found in the efficiency with which he performs the uniform tasks which go into the shift performance. In other words, the type of activity involved in shift is an integral aspect of the activities that make for efficient performance in a simple test situation.

All the findings that have appeared in our study so far converge toward this general principle. It was seen in a previous section that a sharp line cannot be drawn between the adjustments necessary in a uniform activity and the shift required in alternating between two or more uniform activities. It is in keeping with this finding that the individual who performs efficiently in the simpler task will also be efficient in the more complex activity. Similarly, the finding that the more intelligent individual was relatively more efficient in the shift performance supports the principle here involved. The view here proposed, namely that shift-ability is not an isolated factor in the mental organization of an individual but is a close correlate of more general abilities, has implications that lead beyond the field of the present study. Theories as to the existence of special factors, special abilities, faculties, types, idosyncrasies, compensatory traits, have often raised their heads in psychological literature. Opposed to this is the view that a strain of consistency runs through the entire mental and physical equipment of an individual, characterizing his person as a whole. Let us pause for a moment to consider some of the findings which support this view.

It was pointed out earlier in this study that it appeared from Woodrow's investigation of the faculty of attention that the person whose normal reaction time was slow also showed the most prolonged reaction time when the experimental factor of a change in the procedure was introduced: the incompetent person was most susceptible to the effects of the disturbing factor. Culler, in his study of interference and adaptability, found that high initial efficiency in card-sorting was accompanied not only by greater ability to improve with practise but also by greater adaptability in the face of interference. Says he: "This correlation of the plasticity of the individual, his ability to adapt himself to new situations and overcome the ever-present interference, with his initial ability is significant, and gives a clearer and more pronounced index to individual efficiency than the simple practise curve can ever give."[19] Warner Brown,[20] in a study of habit interference in the sorting of cards, found that persons who make a good showing at the beginning of practise retain their relative positions until the end, even though the mechanical conditions of the experiment narrowly limited the amount of improvement that could be made. He also found that high speed when beginning a new order is closely connected with high speed at all stages of the work.

The early history of the study of mental imagery provides interesting illustrations of the concept of special types and individual idiosyncrasies. People were called visualizers, audiles, motiles, and the like. It remained for Betts[21] to show that the separation of men into distinct types according to the predominance of images from one sense was contrary to the actual state of affairs. Instead of distinct types he found continuous gradations: rather than antagonism between the development of imagery from one sense and that from other senses there is a close correlation.

If we go into other fields of psychology, we find similar conditions to hold true. The study of feeble-mindedness has gone to show that on the whole those individuals who are subnormal mentally are also physically below the norm. Studies in criminal psychology indicate that moral degeneracy is frequently a close correlate of mental inferiority. The study of gifted children as compared with children less richly endowed has shown that individuals of superior mentality are "larger, stronger, and swifter, as a group, and that the majority of the former attain puberty at an earlier age than the latter."[22]

An illuminating summary of findings that bear on the problem of idiosyncrasies is given by Hollingworth.[23] In an investigation of the influence of alcohol he found that susceptibility varied inversely with such favorable traits as size and weight, general competence, and ability to improve with practise. These results were borne out by other investigations that had been made. There was the work of Krapelin on susceptibility to such drugs as chloroform, ether, and alcohol. In

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[19] *Interference and Adaptability*, p. 59.

[20] *Habit Interference in Sorting Cards*, Univ. of Cal. Publ. in Psych., Vol. 1, No. 4, pp. 269-321.

[21] *The Distribution and Function of Mental Imagery*, Teachers College, Columbia University Contributions to Education, No. 26.

[22] L. S. Hollingworth, *Gifted Children*, The Macmillan Company, 1926.

[23] Jour. Abn. and Soc. Psych. Nos. 3 and 4, 1924.

analyzing the constitutional basis for individual differences in susceptibility, Krapelin showed that the fatiguable person, and the person with slow reaction time suffers most impairment from the effects of drugs. The work of Schilling on the effect of caffein and acetanilid, and that of Carver on the effects of tobacco smoking also showed that it was the least competent person whose work was most disastrously affected by the drugs. Similar findings appear from Hollingworth's study of the influence of caffein. From an unrelated field, in Allport's study of the influence of a social group on the work of the individual the same results appeared: the inferior person is most affected by a social influence. In a study of over a thousand cases of mental disorder, Hollingworth found that there exists a very similar relation between general mental competence and liability to chronic psychoneurotic symptoms.[24]

From findings of this extensive character emerges the principle of the "positive correlation of desirable traits," or, to use Hollingworth's terms, the principle of the "quality of the organism." The bearing which this principle has upon our present problem is not far to seek. In the analysis of the factors involved in mental set and shift we are led away from the assumption of a special shift factor, innately different with different individuals, and are brought to survey the problem from the general standpoint of stimulus and response.

Every response which an individual makes is in a sense an act of adjustment. Every stimulus that comes to a responding organism is in a sense a test of the adaptability, the power of adjustment, possessed by that organism. The simple reaction time stimulus calls for a simple adjustment; the complex mental task calls for a more complex adjustment. Between the two there is a continuous gradation. When we pass from the isolated simple response to responses of a continuous serial character, we enter a field where the influence of a mental set begins to take form. The mental set is itself an adjustment. It is a response pattern of a given character, called into being by previous stimuli, deriving its strength from previous practise. A mental set, once formed, in turn acts as a stimulus. It initiates preparatory reactions prejudicial to a given type of response. The efficiency of a mental

[24] *Psychology of Functional Neurosis*, D. Appleton, New York, 1920.

set is expressed in part by the degree to which it wards off irrelevant reactions, in part by the facility with which it effects the adjustment required for each successive response.

Just as a mental set is an adjustment in terms of higher units, so shift is an adjustment called into play by a superimposed mental set or by a forced change brought about by a change in the stimuli. The two are inseparable. The uniformity of a mental set, or the high efficiency with which it may operate, does not bespeak the absence of shift. The necessity for shift continues to be operative in the form of constant readjustments even though these may be hidden by the influence of practise or other factors.

With the problem so stated it is not surprising that high efficiency in the separate tasks of the tests used in this investigation goes also with high efficiency in the shift tasks. The separate tasks are tests of an individual's capacity for adjustment, and so are the tests of shift. A sharp line cannot be drawn between the two, nor can a line be drawn between the kind of shift required in one situation as compared with another. The factors that make for efficiency of performance in a given separate task are also operative in a performance calling for alternation between the elements of different separate activities. The type of ability tested where arbitrary shift requirements are made cannot be regarded as a factor existing apart from the type of ability which enters into every response that an individual is called upon to make.

Summary

The outstanding determinant of ability in shift is ability in the separate performances between which shift is made. This holds true not only in performances where the effects of shift are almost negligible but also in those in which shift effects a conspicuous loss. The type of ability which makes for efficient performance in simple and uniform activities also makes for high performance in shift. Accordingly, the ability to shift should be regarded not so much as an isolated factor as an intimate correlate of the general type of ability involved in all response situations.

From the present study we are led to the view that a sharp dichotomy cannot be drawn between mental set and shift. Shift calls for an adjustment on the part of the responding organism, and so does every response which the individual makes. The mental set is itself an adjustment. It involves response patterns of a more or less uniform and integrated character. The effect of a mental set is in part to prevent irrelevant reactions, in part to facilitate the adjustments required by the stimulus situation. The genesis of a mental set lies in previous reaction tendencies, and it derives its strength through practise. When two or more activities, each of which separately operated under the influence of a characteristic mental set, are combined into one performance, new adjustments are required. One of these is the formation of a more comprehensive mental set. From the simple unitary reaction, to the serial responses of a uniform activity, to the serial responses of a more complex and heterogeneous activity, there is a continuous gradation. From the simple reaction to the operation of a simple mental set, and in turn, to the operation of a more comprehensive mental set there is also a continuous gradation. In harmony with this view is the finding that the ability which makes for efficiency in the separate tasks of the present experiments also makes for efficiency in the shift performances.

GENERAL SUMMARY

For complete summaries the reader is referred to the accounts given at the end of each of the preceding chapters. A brief restatement of the main findings will be presented here.

When two or more activities, each of which by itself operates under the influence of a characteristic mental set, are combined into one performance calling for shift from one activity to another, the effects of shift vary with the nature of the activities involved. Within separate and apparently uniform activities there is an element of shift in the form of the readjustments required in passing from one stimulus item to the next; within a performance combining two or more activities there is an element of shift in passing from an item of one activity to an item of another: the shift in the latter situation differs from that of the former not so much in kind as in degree. Factors which influence the efficiency of a task calling for shift from one activity to another are as follows:

The more automatic the adjustments to the successive items within the separate activities, the greater will be the loss effected by shift in the combined performance.

The more unpractised the adjustments to successive elements within the separate activities, the less will be the loss effected by shift in the combined activities; or, in other words, the greater the shift effects within the separate tasks, the less conspicuous the shift effects in the performance combining these tasks.

The factors of overlapping and interference, when operative in the separate activities, are also operative in the performance combining these activities, with the effect of facilitating the shift performance.

Shift is facilitated when the items of the various activities combined into one performance are visibly different, readily distinguishable, or contain associative cues to the appropriate response.

Other things being equal, the greater the time interval required for the response to each of the stimuli between which shift is made, the less will be the relative shift loss.

The effect of practise on a task calling for shift is to bring the performance in this task to a common level with the performance in the separate activities between which the shift is made. The initial conspicuous shift loss in some task combinations is the result not so much of actual interference or retardation as of lack of practise in doing the novel shift task.

In general, the type of ability that makes for high performance in standard intelligence tests also makes for high ability in shifting.

The type of ability that makes for high performance in separate uniform activities also makes for high performance in tasks calling for shift from one activity to another. When two or more activities are combined into one shift performance, a more comprehensive mental set is formed to meet this new situation. The individual who reacts most efficiently in the simple activities also makes the most efficient adaptation to the more complex situation.

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