NORMAL CHANGES IN THE MENTAL ABILITIES OF ADULTS AS AGE ADVANCES.

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I. Introduction.

It is generally recognized that the capacity to grasp new ideas and learn new methods of work depends partly upon a person's intelligence and partly upon his age. It is also recognized that over-taxing a person's capacity to acquire new methods of work, or inadequate opportunities for a person to develop the capacity he possesses, are sources of dissatisfaction, mental strain, and sometimes physical complaints amongst normally healthy people. There is even reason to believe that amongst less healthy people they contribute towards disaffection and illness.

During 1944–45 the G.P.O. Engineering Department, Scotland, and Messrs. ———, Ltd., London, asked permission to use mental tests which they thought would assist them to select, in economic proportions, suitable staff to meet the requirements of their organizations. These requests opened a matter of considerable psychological interest. The G.P.O. Telephone Service and Messrs. ———, Ltd., are branches of industry requiring men capable of acquiring specialized training. The greater part of the staff of each is recruited in youth, and remains in the same organization until the retiring age of 60 to 65. The chief difference between them is that one is a national monopoly, the other a competitive industry. The two requests therefore offered a unique opportunity for a comparative study of the distribution of mental ability in a competitive and non-competitive industry, and for assessing, with considerable accuracy, normal changes in mental ability with age.

For these reasons the Crichton Royal Department of Psychological Research asked the G.P.O. Headquarters and the Directors of Messrs. ———, Ltd., for their co-operation in an investigation designed to provide information concerning the assessment of general trainability and normal variations of this ability with age. The requests received the support of the administrative and staff sides of each organization, and in 1946 a plan for two exactly parallel surveys was put into operation.

The agreed object was :

(*a*) For the organizations co-operating to obtain information concerning methods which would assist them in recruiting the right kind of staff in the right proportions without making excessive demands upon people not naturally equipped to meet them, and without training men of good ability in such numbers that their chances of promotion would be unduly delayed. This aspect of the investigation is reported elsewhere (1).

(*b*) For the Crichton Royal to obtain information concerning normal changes in the intellectual abilities of adults as age advances, and statistical

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data which would contribute towards standardizing the tests they wished to use.

II. The Men Tested.

At meetings with the staff of each organization the reasons for the investigation were explained to the men. To secure their co-operation, even if they thought they were less able than other men, it was also explained that a method would be used whereby those volunteering to do the tests need not put their names on their test papers. Information concerning each person's age, year of entering, grade of occupation on entry and present work was provided for the entire male staff of each organization. This information was coded and recorded in advance on each volunteer's test record form. In this way it was possible to classify the men according to the kinds of work in which they were engaged, and to compare the men tested with the remainder of the staff in their own organization, and with men engaged in any other occupation (1).

Table I shows, for each five-year age group between 15 and 65, the number and percentage of men in each organization who did the tests, and the relative size of each age group in the sample. As age advances there is seen to be a slight decline in the percentage of people who volunteered. Minor fluctuations in one organization are in most cases offset by fluctuations in the other, except for the group of men over 60 years of age. For both organizations this group is too small to be considered adequate. The engineers show an unusually high proportion of men in their 30's. Table II shows the number and percentage in each occupational group who did the tests, and thence the degree

Table I.—*Distribution of Volunteers According to Age.*

Age group.	G.P.O. Engineers.			Messrs. —— Ltd., male employees		
	Number tested.	Percentage of staff.	Percentage of sample.	Number tested.	Percentage of staff.	Percentage of sample.
15–19 years	91	55	9	78	30	8
20–24 ,,	88	53	8	52	27	6
25–29 ,,	151	45	14	114	36	12
30–34 ,,	231	45	22	128	32	14
35–39 ,,	162	38	15	122	30	13
40–44 ,,	90	40	9	144	30	16
45–49 ,,	87	39	8	116	30	12
50–54 ,,	85	51	8	70	24	8
55–59 ,,	49	32	5	67	35	7
60–64 ,,	13	23	1	29	18	3

Table II.—*Distribution of Volunteers According to Occupational Group.*

Occupational group.	G.P.O. Engineers.			Messrs. —— Ltd., male employees.		
	Number tested.	Percentage of staff.	Percentage of sample.	Number tested.	Percentage of staff.	Percentage of sample.
Directive or executive	85	57	8	34	32	4
Workmen (highly skilled)	234	48	22	159	34	17
Workmen (skilled)	328	40	32	242	32	26
Workmen (qualified)	296	39	28	240	34	26
Unskilled workmen	54	39	5	153	20	16
Youths-in-training without skilled date	50	52	5	63	40	7
Unclassified assistants, etc.	—	—	—	29	22	3

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TABLE III.—*Distribution of Volunteers According to Method of Entry.*

Occupational grade.	G.P.O. Engineers.			Messrs. —— Ltd., male employees.		
	Number tested.	Percentage of staff.	Percentage of sample.	Number tested.	Percentage of staff.	Percentage of sample.
Youths	359	49	34	101	34	11
Unskilled workmen	384	38	37	520	27	57
Skilled workmen	266	43	25	262	33	28
Academically trained men	38	51	4	37	39	4

TABLE IV.—*Present Ages of Staff Recruited as Youths.*

Present age.	G.P.O. Engineers.		Messrs. —— Ltd., male employees.	
	Number tested.	Percentage of total staff.	Number tested.	Percentage of total staff.
16–19 years	85	57	27	26
20–24 ,,	79	53	24	41
25–29 ,,	95	45	21	35
30–34 ,,	22	55	13	33
35–39 ,,	12	33	11	65
40–44 ,,	9	26	1	—
45–49 ,,	34	53	3	—
50–54 ,,	23	53	—	—
55–59 ,,	—	—	1	—

TABLE V.—*Age at, and Year of Entry of Staff Recruited as Unskilled Workmen.*

G.P.O. Engineers:

Year of entry.	Age of entry in years.										Total for year of entry.
	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	
1902–06	1	—	—	—	—	—	—	—	—	—	1
1907–11	7	2	—	—	—	—	—	—	—	—	9
1912–16	2	9	4	—	—	—	—	—	—	—	15
1917–21	—	9	7	1	1	—	—	—	—	—	18
1922–26	—	6	13	4	2	—	—	—	—	—	25
1927–31	—	2	4	1	2	—	—	—	—	—	9
1932–36	1	54	55	28	11	5	—	—	—	—	154
1937–41	1	43	25	17	7	4	6	5	—	1	109
1942–46	—	5	10	14	5	1	1	5	—	3	44
Total for age of entry	12	130	118	65	28	10	7	10	—	4	384

Messrs. ——, Ltd., Male Employees:

1902–06	2	—	—	—	—	—	—	—	—	—	2
1907–11	5	3	—	—	—	—	—	—	—	—	8
1912–16	7	3	2	2	—	—	—	—	—	—	14
1917–21	5	6	2	3	2	—	—	—	—	—	18
1922–26	10	9	7	—	2	1	—	—	—	—	29
1927–31	25	19	13	7	5	1	1	—	—	—	71
1932–36	34	19	19	18	5	1	—	—	—	—	96
1937–41	51	19	16	19	9	19	20	9	..	2	164
1942–46	50	4	10	9	10	12	8	9	5	1	118
Total for age of entry	189	82	69	58	33	34	29	18	5	3	520

to which each sample can be regarded as a representative cross-section of the entire organization. Table III shows, for the men co-operating, the numbers who entered each organization as boys, as unskilled or as skilled workmen, and as men with technical or University qualifications. Table IV shows the present ages of the men who entered each organization as boys. Amongst the engineers, some of these are now over 50 years of age. For Messrs. ———, Ltd., the group is much smaller; at present they are nearly all under 40 years

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TABLE VI.—*Age at, and Year of Entry of Staff Recruited as Skilled Workmen.*

G.P.O. Engineers :

Year of entry.	Age of entry in years.										Total for year of entry.
	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	
1902–06	1	—	—	—	—	—	—	—	—	—	1
1907–11	2	1	—	—	—	—	—	—	—	—	3
1912–16	5	8	6	2	—	—	—	—	—	—	21
1917–21	—	1	—	—	—	—	—	—	—	—	1
1922–26	—	6	2	1	—	—	—	—	—	—	9
1927–31	—	2	1	—	1	—	—	—	—	—	4
1932–36	2	31	16	10	5	2	1	—	—	—	67
1937–41	2	51	45	19	4	—	1	—	—	—	122
1942–46	—	1	12	16	6	2	1	—	—	—	38
Total for age of entry	12	101	82	48	16	4	3	—	—	—	266

Messrs. —— Ltd., Male Employees :

1902–06	2	—	—	—	—	—	—	—	—	—	2
1907–11	—	1	2	—	—	—	—	—	—	—	3
1912–16	2	3	5	—	—	—	—	—	—	—	10
1917–21	3	2	3	3	—	—	—	—	—	—	11
1922–26	6	12	3	4	4	—	—	—	—	—	29
1927–31	1	11	16	5	6	5	1	—	—	—	45
1932–36	1	10	17	7	6	2	—	1	1	1	46
1937–41	3	17	14	16	9	8	8	—	—	—	75
1942–46	—	6	5	10	5	8	3	3	1	—	41
Total for age of entry	18	62	65	45	30	23	12	4	2	1	262

of age. Table V shows, for the men entering each organization as unskilled workmen, the period during which they were taken on, and their ages at the time. Table VI gives a similar analysis of the men entering each organization as skilled workmen. From Table V it is seen that a high proportion of G.P.O. Engineers at present in their 30's were recruited as unskilled workmen during the slump period 1932–36. This was part of a Government policy to provide work for unemployed men. From Table VI it is seen that during the period 1937–41, the G.P.O. Engineering Department took on a high proportion of skilled workmen now in their 30's. During the period 1937–46 Messrs. ———, Ltd., took on a high proportion of unskilled workmen of all ages from 15 to over 60, a large proportion being boys under the age for military service.

III. THE TESTS USED.

The tests used were Progressive Matrices, 1938 (2), and the Mill Hill Vocabulary Scale, Form I (3). These two tests were constructed for use together in order to show in a distinct and clearly defined form (*a*) a person's present capacity for intellectual activity, and (*b*) the level of his present intellectual attainments relative to other people. Both tests had been standardized for children 6 to 14 years of age. The Matrices Test had also been standardized for men 20 to 25 years of age(4). The tests still needed to be standardized for older people.

Progressive Matrices (1938) is a non-verbal test of a person's capacity at the time of the test to form comparisons, reason by analogy, and develop a logical method of thinking regardless of previously acquired information.

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TABLE VII.—*Re-test Reliability and Inter-Correlation of Progressive Matrices (1938), and the Mill Hill Vocabulary Scale, at Different Ages.*

Age range.	Number tested.	Matrices Test.			Vocabulary Test.			Correlation between P.M. and M.H.V. scores.
		First test.		Re-test reliability.	First test.		Re-test reliability.	
		Mean score.			Mean score.			
Under 30	44	48	8·2	·93	41	15·7	·97	·60
30–40	104	37	9·5	·88	33	8·9	·91	·51
40–50	106	35	11·2	·87	31	9·0	·98	·45
50 and over	77	29	10·5	·83	31	12·1	·90	·44

In other words, it is a test of a person's capacity to understand and apply a fresh method of thinking. It is in no sense a test of any specific ability or aptitude, but it has repeatedly proved to be a valuable test of a person's normal capacity to learn any particular knowledge or technical skill he may desire to acquire.

The Mill Hill Vocabulary Scale is a test of the general fund of information a person has acquired as the result of intellectual activity in the past. It does not indicate what a person will in future be able to learn, but it provides one of the most satisfactory means of determining the best level of intellectual development a person has attained in the past, whatever his present capacity for intellectual activity may happen to be.

IV. Re-Test Reliability and Inter-correlation of the Tests.

During 1943 the two tests were given in their standard form without a time limit to 331 men of the Civil Defence Light Rescue Squads in North London. The men were re-tested a month later. Table VII summarizes the results. According to both tests, the men under 30 years of age are, as a group, more able than the rest. (The group contained a number of conscientious objectors.) For the men over 30 years of age, the mean Vocabulary Test score remains relatively constant. The mean Matrices score, on the other hand, declines noticeably. The Matrices re-test reliability is seen to decline also. One possibility is that low scores on the test are in themselves less reliable than high scores. It should, however, be noticed that the Vocabulary Test reliability also declines as age advances. Another possibility is that as a result of asking a person to choose right answers out of groups of alternatives, the lower his genuine score the greater the number of opportunities he has of choosing the right answers by chance alone. The same decline in reliability, however occurs when the definition half of the Vocabulary Test is considered by itself. Clinical work with the tests suggests that low re-test reliability and inter-correlation represent a genuine variability in the output of intellectual activity under certain conditions. Both tests show the highest re-test reliability and inter-correlation when they are given to healthy people 12 to 30 years of age. The lower re-test reliability and inter-correlation obtained when they are given to little children, old people, mental defectives, and people who are mentally ill, is probably due in part to chance factors, but more to a greater variability in the intellectual activities of such people. Whatever the explanation may be, it is clear that a distinction must be made between the results of unreliable tests and the test results of unreliable people.

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More accurate information concerning re-test reliability at different ages and the degree to which it represents genuine variability of mental output is urgently needed. This information could only be obtained from an investigation planned for the purpose. In the present investigation, to secure the co-operation of men of all ages, it was necessary to let those co-operating remain anonymous if they wished. As a result, it was not possible to re-test the men and investigate the psychological significance of differences between the first and second test results.

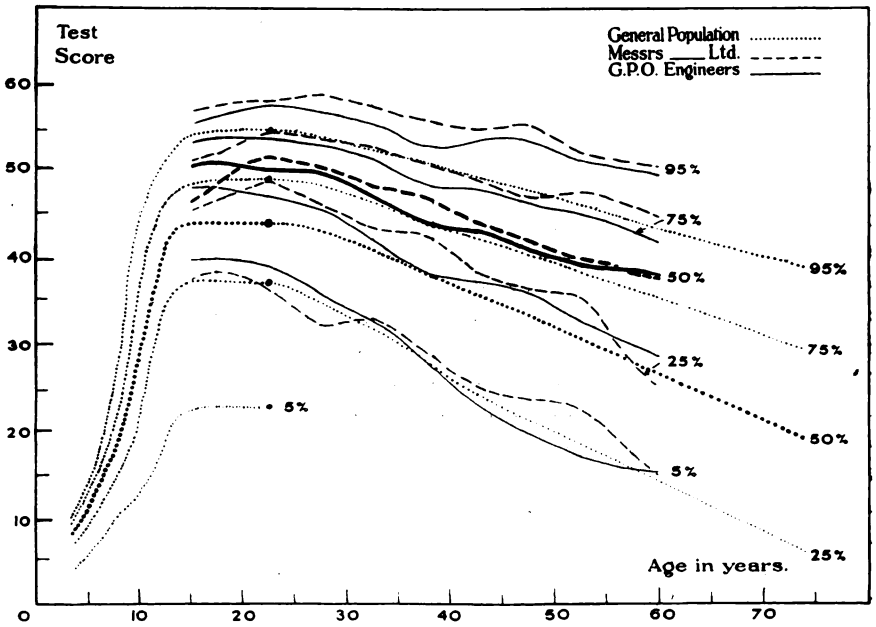
V. Variations in the Test Scores with Age.

The selected men who agreed to do the tests attended at stated times, and were tested in groups of about 25 to 30. The tests were carried out between 9 a.m. and 4.30 pm., and were administered according to the standard procedure. No time limits were imposed. The times of beginning and ending each test were noted, and a quarter of an hour between each group was allowed, to minimize disturbances. The trends in the test results for the men entering each organization as boys, as unskilled and as skilled workmen were sufficiently alike to warrant combining the three groups in order to determine the general changes in the test scores with age.

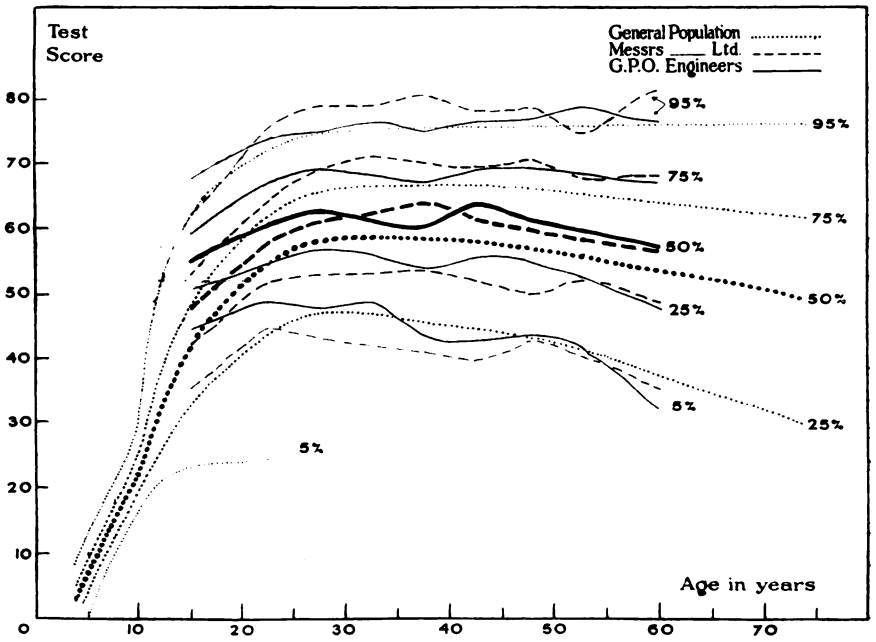
In Graph I, changes in the Matrices Test scores between the ages of 17 and 60, for 1,047 G.P.O. Engineers, are compared with changes in the test scores for 920 male employees of Messrs. ———, Ltd. The 5th and 95th percentile curves indicate, for each organization, the neighbourhood of the upper and lower extremes of the score distributions. The 25th and 75th percentile curves indicate the extremes between which lie the scores obtained by 50 per cent., or the main body of the men. The 50th percentile curve indicates the median or central score for each group. With one or two exceptions the percentile curves for the two organizations show a surprising similarity. The 5th and 95th percentile curves are susceptible to chance variations in the groups considered. For the employees of Messrs. ———, Ltd., the 25th, 50th, and 75th percentile curves show a marked downward trend in the scores obtained by men under 25 years of age, but it has already been noted that during the past ten years they have been taking on an unusually large number of unskilled youths. Recently they have in fact been compelled to employ almost any boy who applied to them for work.

For G.P.O. Engineers in their 30's there is an accentuated decline in the average Matrices Test score. For the employees of Messrs. ———, Ltd., the exact opposite occurs. It has already been noticed that during the slump period, the G.P.O. Engineering Department intentionally took on a large number of young, unskilled workmen, who are now in their 30's. During this period Messrs. ———, Ltd., were able to select the best men from a large number of applicants. In the neighbourhood of 60 years there are less consistent variations in the percentile curves. This is probably due to the fact that the numbers of men tested were small. Apart from this, most of the fluctuations in the percentile curves for one organization are offset by opposite fluctuations in the percentile curves for the other organization. In

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GRAPH I.—Variations in the progressive matrices test score.



GRAPH II.—Variations in the Mill Hill Vocabulary test score with age.

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general, the rate of decline in the Matrices Test scores from the age of 25 onwards is seen to be surprisingly uniform, and to be independent of the particular kind of work in which the men are engaged, or the conditions of employment.

The Progressive Matrices had already been standardized for men 20 to 25 years of age (4). In order to standardize the test for adults over 25 years of age, it was therefore possible to start with the established percentile points for men 20 to 25 years of age, and exterpolate each in accordance with the observed mean rate of change at that score level at successive intervals of five years. As the large majority of the men in the two organizations proved to be of average, or more than average ability, the normal 95th to 50th percentile curves could in this way be established with considerable accuracy. With slightly less accuracy it was also possible to exterpolate the normal 25th percentile curve. The investigation, however, provided insufficient information for it to be possible to determine changes in the 5th percentile score after the age of 25. The dotted curves indicate the established Matrices percentile points for children, and for men 20 to 25 years of age. They also indicate what are inferred to be the normal changes between the ages of 25 to 60, and after this, if we assume that the changes continue uniformly.

Graph II shows, for each organization, variations in the Vocabulary Test score with age. Compared with the G.P.O. Engineers, the percentile curves for the employees of Messrs. ———, Ltd., show the same steep downward trend for men under 25 years of age, due to the fact that at the present time they have to take almost any boy who applies to them for work. They also show the same peak in the 30's compared with a drop in the scores for the Engineers, due to the fact that during the period 1932–36 the G.P.O. took on a large number of young, unskilled men, while Messrs. ———, Ltd., could select their staff from a large number of applicants. According to the median Vocabulary Test scores, the Engineers appear, as a group, just slightly more able than the employees of Messrs. ———, Ltd. According to the Matrices Test scores, they appear, as a group, just slightly the reverse. The difference may reflect a greater thoroughness of education in Scotland, or fewer outdoor leisure interests. Unlike the Matrices Test, the Vocabulary Test percentile curves show, for both organizations, a consistent rise in the scores up to about the age of 30. After this they remain practically constant up to the age of 60.

For the Vocabulary Test, the normal dispersion of scores for men between 20 and 25 years of age was not already known. In order to fix the chief percentile points at maturity, a pool was therefore made of all the available test records for normally healthy men 17 to 30 years of age, obtained in this and other investigations. To this was added a group of test records for men of similar ages, but known to be definitely below the average in intellectual ability. From this pool records were drawn until at the average age of 20 and 25, two populations were built up in such a way that for each age group the Matrices Test scores were distributed in agreement with the distribution obtained from Militiamen in 1941 (4). The Vocabulary Test scores for each population were subsequently used to compute the normal percentile distribution at 20 and at 25. The chief percentile points obtained for men age 20 $\pm$ 3 years, and men aged 25 $\pm$ 5 years, are shown in Table VIII. Unlike

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TABLE VIII.—*Mill Hill Vocabulary Scale Percentile Points Calculated for a Normalized Sample of* 156 *Men* 20 ± 3 *years, and* 268 *Men* 25 ± 5 *years.*

Percentile points.	Average age.	
	20.	25
95	71	74
90	65	72
75	59	66
50	**51**	**58**
25	39	48
10	27	33
5	22	26

the scores obtained with the Matrices Test, there is a noticeable increase in the Vocabulary Test scores after the age of 20. The increase is relatively uniform throughout the distribution, and suggests that the normalized samples used are moderately consistent. With the normal Vocabulary Test percentile points at least tentatively established for men 20 to 25 years of age, it was possible to exterpolate the 25th to 95th percentile points up to the age of 60, in the same way as it was possible to exterpolate them for the Matrices Test scores.

VI. Inferences Concerning Normal Changes in Mental Ability with Age.

According to Graph I, the capacity to form comparisons and reason by analogy increases rapidly during childhood, appears to reach its maximum somewhere about the age of 14, after which it remains relatively constant until from about the age of 25 onwards it slowly declines. If the decline continues at a similar rate after the age of 60, it would appear that by the age of about 80, the average person's capacity to grasp fresh ideas and adopt new methods of working has ceased to be greater than that of a child of eight. This is important in view of the fact that before the age of 8 years the average child is incapable of forming abstract comparisons and reasoning by analogy, at least as a systematic method of learning. According to Graph I this would appear to apply equally well to old people. This is interesting as, in work carried out with seniles (5), it has already been found that old people can only understand the test at all if it is given to them in the form of boards and moveable pieces, just as one would give the test to a little child, and that when it is given to them in this form, it is one of the very few tests which they can understand and carry out at all effectively.

According to Graph II, the average person's ability to recall information normally increases up to the age of at least 25, and from about the age of 30 onwards remains relatively constant for about 25 years, after which it apparently declines a little. For people above the average, ability to recall information apparently continues to increase slowly even up to the age of 60. For people below the average the opposite appears to be the case. What ability they acquire in youth appears to decline fairly early in life.

With minor exceptions, the findings are in agreement with the findings of other investigators (6, 7, 8, 9). They are also in agreement with the generally

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accepted view that from about the age of 30 onwards a person's ability to understand new methods of thinking, adopt new methods of working, and even to adjust to new situations, steadily decreases, whereas he is normally able to recall acquired information long after his capacity to adapt to new situations has begun to decline. The findings also support the view that a Vocabulary Test gives an index of the best level to which an individual has attained, whatever his present capacity for intellectual activity may be (10).

We still need more accurate information concerning normal changes with age occurring amongst people definitely below the average in intellectual capacity, and more representative groups of test records for people 15 to 30 years of age. Information is also needed concerning the normal changes after the age of 60. At present there is inadequate information concerning changes in the re-test reliability with age, and the degree to which they indicate increased variability of mental output as distinct from the unreliability of the test score in itself. Investigations so far completed, however, provide us with considerable information concerning normal changes in the test scores of adults of average, or more than average, intellectual capacity, and it is anticipated that subsequent investigations will fill at least some of the gaps in our present knowledge.

Acknowledgments.

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