SOME OBSERVATIONS UPON PRACTICE AND FATIGUE AS THEY AFFECT THE RATE OF TAPPING[1]

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These observations were taken to determine how different periods of rest might affect the rate of movement in successive trials at taping and what might be the rate of practice gain in a series of observations taken for a number of successive days. The observations were made upon three regular reagents and the students who came into the laboratory by chance and for the regular laboratory work in the practice course. A single trial at tapping lasted for five seconds and five periods of tapping separated by different periods of rest were made to follow one another. The rest periods were five, ten or twenty seconds. Five trials at any given rest period are called an observation and six observations, three with either hand at the three different rest periods, constitute a record. Usually four observations were taken at a sitting, two with either hand, and only one sitting a day was allowed. The hands were alternated in beginning the successive observations and the tapping was begun each day at a rest period different from that at which it was begun the day before. In this way the after effects of previous tapping were as nearly equalized as possible. Upon reagent B_1 thirteen records were taken, upon B_2 sixteen and upon Ph twelve. The students made only a single record. Of the students there were two classes. The first class took their observations in irregular order, some beginning with one rest period and some with another. About an equal number began with each rest period. In the second class all began wth the twenty-second rest period, then followed the ten and finally the five. The mental after-effects of tapping with five second rest periods are felt for some time—several hours perhaps. While after-effects from the other periods are not observable for more than a few moments introspectively, they may still exist and affect the subsequent rates of tapping. If, however, records are taken with only one rest period, the practice effects, which are much more easily demonstrable than the temporary after-effects just referred to, will affect any subsequent work with the tapping test for many weeks. Consequently the plan of equalizing these various results by alternating the different rest periods was chosen.

The tapping was done upon a lever attached to the escapement of a clock. A hand was rigged to one of the wheels and this passed over the face of a dial. The time was taken with a stop watch. In the following table are given as general results, the average number of taps for either hand in the five successive trials and for all three rest periods. In one or two cases a figure was copied incorrectly so that the record was thrown out. Three observations from the records of Ph and one from the record of B_1 are wanting.

[1] This work was done under the direction of Professor T. L. Bolton in the psychological laboratory at the University of Nebraska.

TABLE I.

Reagent B1.

	Right Hand					Left Hand				
	5 sec. rest. 12 records.									
Trials.	1	2	3	4	5	1	2	3	4	5
Av. Taps	36.5	36.08	37.08	36.08	36.16	34.33	36.75	35.0	34.25	34.25
	10 sec. rest. 13 records.									
Av. Taps	35.69	38.53	36.3	36.07	35.61	32.84	35.3	35.07	34.61	34.0
	20 sec. rest. 13 records.									
Av. Taps	36.61	36.61	36.38	35.84	36.61	35.15	38.38	35.0	35.35	35.76

Reagent B2.

	5 sec. rest. 13 records.									
Av. Taps	38.15	37.0	37.0	36.61	37.76	37.46	36.84	36.15	36.07	36.53
	10 sec. rest. 18 records.									
Av. Taps	37.83	38.5	39.0	38.5	38.72	37.94	39.16	37.94	38.61	38.11
	20 sec. rest. 16 records.									
Av. Taps	38.0	38.31	39.25	39.06	39.31	39.56	39.0	39.37	39.87	40.81

Reagent Ph.

	5 sec. rest. 12 records.									
Av. Taps	43.75	43.08	43.41	43.08	43.16	44.41	43.25	42.83	48.75	41.33
	10 sec. rest. 12 records.									
Av. Taps	46.00	44.16	44.25	44.41	44.00	46.91	44.50	44.41	43.33	44.00
	20 sec. rest. 9 records.									
Av. Taps	42.88	42.11	42.22	43.22	43.88	45.55	44.44	44.44	44.33	44.22

Class Records. First Division.

	5 sec. rest. 38 records.									
Av. Taps	39.10	39.07	38.28	37.75	37.78	35.10	34.71	34.71	35.25	33.92
	10 sec. rest. 24 records.									
Av. Taps	38.25	39.25	38.95	39.66	39.33	36.41	36.20	35.87	35.37	35.58
	20 sec. rest. 26 records.									
Av. Taps	39.26	39.61	38.61	38.30	38.03	35.76	36.53	36.42	36.15	35.84

Class Records. Second Division.

	5 sec. rest. 31 records.									
Av. Taps	39.61	40.54	39.32	38.64	37.29	37.22	36.54	35.58	36.74	36.00
	10 sec. rest. 32 records.									
Av. Taps	40.40	40.62	39.81	40.06	39.03	37.03	37.18	36.62	36.40	36.78
	20 sec. rest. 32 records.									
Av. Taps	38.58	38.78	38.40	40.06	39.71	36.22	37.03	35.15	36.39	36.65

From these figures the average gain or loss in the five successive trials for all rest periods and both hands was computed. The average gain or loss for the five successive trials is given in Table II following:

TABLE II.

Reagent B1.

	Right Hand.		Left Hand.	
	Gain	Loss	Gain	Loss
5 sec. rest	——	.175 taps	——	.145 taps
10 sec. rest	——	.123 "	.161 taps	——
20 sec. rest	——	.067 "	——	.084 taps

Reagent B2.

	R. H.		L. H.	
	Gain	Loss	Gain	Loss
5 sec. rest	——	.114 taps	——	.307 taps
10 sec. rest	.177 taps	——	——	.022 "
20 sec. rest	.377 "	——	.337 taps	——

Reagent Ph.

	R. H.		L. H.	
	Gain	Loss	Gain	Loss
5 sec. rest	——	.110 taps	——	.900 taps
10 sec. rest	——	.375 "	——	.700 "
20 sec. rest	.311 taps	——	——	.277 "

Class Record. First Division.

	R. H.		L. H.	
	Gain	Loss	Gain	Loss
5 sec. rest	——	.470 taps	——	.182 taps
10 sec. rest	.258 taps	——	——	.266 "
20 sec. rest	——	.376 taps	——	.231 "

Class Record. Second Division.

5 sec. rest	——	.687 taps	——	.035 taps
10 sec. rest	——	.331 "	——	.153 "
20 sec. rest	.334 taps	——	.120 taps	——

The figures in this table show that when a five second rest period is allowed between the successive trials at tapping there is an average loss for all reagents. When the ten second rest is allowed, there is generally a less average loss than with a five second rest or there is an average gain. Two cases of the latter are found, the left hand of B_1 and the right hand of B_2. With a twenty second rest period the average loss is generally less than with either the five or ten second rest period, or there is a decided average gain. In the possible ten cases three times a greater loss is made with the ten and twenty second rest periods than with the five, and in two cases the ten second rest period shows a gain where a small loss is shown in the twenty second rest period. The evidence, however, that the twenty second rest is the most favorable pause between five second periods of tapping is fairly conclusive.

If the algebraic sum of the losses and gains for the three reagents and the two classes of students for each rest period is taken, the following figures are obtained:

	R. H.	L. H.
5 sec. rest	1556 loss	1559 loss
10 sec. rest	604 loss	1302 loss
20 sec. rest	739 gain	135 loss

The right hands show for the ten second rest less loss than for the five second rest and for the twenty second rest a considerable gain. The left hands show a loss decreasing inversely with the length of the rest period. The left hand thus responds less clearly to the favorable condition of a longer pause than the right. This is about what we should expect, although when the total amounts of work done by either hand and for all three reagents were computed, it was found that they are all practically ambidextrous. B_1 and B_2 are perhaps slightly right-handed and Ph is with equally small amount left-handed. While then the two hands have done about equal amounts of work, they have arrived at this result by different roads. Being less accustomed to voluntary direction, the left hand would not profit so readily by favorable conditions.

Another method of treating these results is here offered which shows well what has actually been transpiring. If the average rates of tapping for the successive trials for the three rest periods and both hands are taken separately and arranged by the ordinal numbers in the order from the highest to the lowest and the ordinal numbers are then added up, an expression for the place where the slowest rate of tapping is found will be obtained. Let this illustrate the method which we propose here to follow: For the right hand of reagent B_1 at the five second period of rest, the highest rate of tapping was found in the third trial and the next highest in the first trial, the fifth trial was third, the second was fourth and the fourth trial the lowest or fifth. The five trials for each reagent and the two classes are then arranged in the same way for both hands and for each rest period and the sums of the five columns are then taken. The result is given in the following tabular statement:

TABLE III

Five Second Rest

	R. H.					L. H.				
B_1	3	1	5	**2**	4	2	3	1	4	5
B^2	1	5	2	3	4	1	2	5	3	4
Ph	1	3	5	2	4	4	1	2	3	5
Cl I	1	2	3	4	5	4	1	2	3	5
Cl II	2	1	3	4	5	1	4	2	5	3
Total	8	12	18	15	**22**	12	11	12	18	**23**

Ten Second Rest

Total	12	**18**	14	14	14	7	14	17	**20**	18

Twenty Second Rest

Total	**17**	15	16	14	13	12	**19**	16	14	13

We have omitted the individual records and given only the sums of the five columns under the ten and twenty second rest periods. For the five second period the highest figures are found under the fifth column which means that the lowest rate of tapping was found here in the fifth trial. For the ten second period the slowest rate of tapping was at the second trial with the right hand and at the fourth trial with the left hand. For the twenty second period the slowest rate was at the first trial with the right hand and at the second trial

with the left hand. In other words the slowest rate has moved from the fifth place with the five sec. rest to the first place with the twenty sec. rest. This process of shifting has been slower with the left hand than with the right hand; it has lagged behind two places for the left hand with the ten seconds rest and it has reached only the fourth place with the left hand with the twenty sec. rest. Two main influences that act together to determine the amount of work that can be done within a given time and under given circumstances are fatigue and practice. Other influences pointed out by Kraepelin are beginning incitement, concluding incitement (finishing spurt) and warming up. If Wells's usage of the term "warming up" as an increase in rate of work during a period of continuous work rather than an increase which takes place between successive periods of work[1] is to be accepted and adopted, then none of the last three mentioned influences need to be considered here. Only interserial rather than intraserial changes have been studied here. While this distinction is well taken in the main, a further word for its broader usage will be offered. With the five sec. rest there is a continued loss in amount of work in successive trials. With the twenty sec. rest for the right hand there is a continued gain and for the left hand the gain begins only after the second trial. The five second rest is clearly inadequate to dissipate the effects of the fatigue of the preceding trial. Fatigue here outweighs practice or other accelerating factors. Twenty seconds seem fully sufficient except after the first trial with the left hand. Here there seems to be another phenomenon. The reagents complained of losing interest during the twenty second rest; they spoke of finding it difficult to keep themselves 'keyed up' for that length of time. The term "warming up" might then be made to cover this phenomenon of being keyed up or of not losing interest or excitement. Fatigue would still cover interserial gain, but it does not seem quite applicable for the gain showing after such short rest periods. With the ten second rest there is first a loss in work power and then a gain. This process of getting keyed up, excited or "warmed up" here takes some time so that at first fatigue overbalances any gain through practice, but later when the excitement has arisen, the speed of work increases with successive trials. When the average trial gain is taken, both hands show a loss, the right showing less loss than the left. The results in this last table show that the left "caught its pace" later than the right which harmonizes with the greater loss for the left than for the right.

The following table contains the average daily gains for the sums of the five trials.

TABLE IV.

Reagent	Hand	5 sec.	10 sec.	20 sec.
B_1	R.	3.234	2.027	1.494
	L.	2.770	2.410	2.500
B_2	R.	1.247	.566	.836
	L.	3.129	1.983	2.011
Ph.	R.	4.120	4.270	2.800
	L.	1.741	.923	1.360
	Total	16.241	12.179	11.001

The result is that the average daily gain is inversely as the length of the rest. The practice gain seems to be great in proportion as the

[1] F. L. Wells: Normal Performance in Tapping Test, *Amer. Jour. Psych.*, Vol. XIX, p. 446.

work is fatiguing. In view of this fact it may be said that, if the series were to continue long enough, the five second rest might prove the most favorable to the work capacity of the reagent. In Table III we might expect that for all rest periods the highest numbers would shift to the first places as the highest number is now found in the first place for the twenty second rest with the right hands. It is evident that in instituting comparisons between different grades of intellect, between classes of persons doing different kinds of work and between the normal and abnormal subjects, account must be taken of the practice efficiency in which the various subjects may find themselves at the time of the tests. Kraeplin's suggestion that we must study in such comparisons the manner in which the rates of practice gain are affected is in point here. Further work must be done to show how the curve of practice behaves and to determine the permanence of any practice effects that may be made and the likelihood with which they will appear in short and long series. Results gained from applying tests to different classes of subjects whose differences are alleged only upon the basis of common observation must be weighed with extreme care and conclusions drawn only with deliberate precaution.

In order to determine in what part of the series the greatest gain was made the observations were divided in the middle and the average daily gains were computed for each division. In the following table are given the algebraic differences between the gains or losses for the first and second halves. Where the second half has shown an advantage over the first half the figures are marked 'g' and where the result has turned out in favor of the first half 'l' is placed after the figures.

Right hand

Reagent	5 sec.	10 sec.	20 sec.
B_1	.233 g	.178 g	.025 l
B_2	.866 g	.358 g	.043 l
Ph	.566 g	.617 g	1.200 g
	1.865 g	1.153 g	1.132 g

Left hand

	5 sec.	10 sec.	20 sec.
B_1	.300 g	.133 l	.250 g
B_2	.530 g	.293 l	.214 g
Ph	.400 g	.100 l	.025 g
	1.230 g	.526 l	.948 g

All these records, except those for the left hands with the ten sec. rest, show a decided advantage in favor of the second half. In carrying out a piece of work fatigue makes itself felt first and practice gain disappears in counteracting the effects of fatigue. Practice consists in part in overcoming fatigue. The greatest advantage of the second half over the first is shown for the five sec. rest where the greatest average daily gain was made. It might be pointed out further that reagent B_1 who showed least fatigue loss gains least during the second half and reagent Ph who was most affected by fatigue shows here a decided advantage as gaining most during the second half.

The general conviction that practice gain is in proportion to the amount of fatigue engendered by the work is supported by the results. One must work up to his maximum, where he suffers most fatigue, that he may profit most by his work in the way of practice gain. The first object of practicing an effort is to overcome the depressing and

inhibiting effects of fatigue and even throughout any series of efforts a certain amount of the practice effect is lost through habituation of the reagent to the newer conditions imposed by the gains already made by practice. After a certain number of trials, however, the reagent is affected less and less by the mental symptoms of the work and the practice shows itself by the increased amounts of work done within a given time interval.

In conclusion it may be said that with five sec. trials at tapping the rest periods, five, ten and twenty sec. are favorable to work in an order the reverse of that in which they stand here and that these rest periods are favorable to practice gain in the order here given. With these rates of daily gain it is not improbable in a long series that the shortest rest period might prove the most favorable. It is suggested that before this test can be used as a basis of comparison for different classes of subjects tests must be made upon more subjects with only one rest period at a time, that they be continued for a longer time, and that other periods of tapping, ten and twenty seconds, be tried with the same and longer periods of rest. The standardization of the various psychological tests is imperatively demanded before further work in using them is done.