THE DYNAMOGENIC FACTORS IN PACEMAKING AND COMPETITION.

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This paper gives some facts resulting from a study in dynamogenic stimulation carried on in the Psychological Laboratory of Indiana University and their application to explain the subject of Pacemaking and Competition

The work has been done under the direction of Dr. W. L. Bryan and Dr. J. A. Bergstrom, to both of whom I am greatly indebted for the help rendered throughout its progress.

A copy of the official bicycle records made up to the close of the season of 1897 was obtained from the Racing Board of the League of American Wheelmen, and from these records certain facts are given, which, with the help of the chart showing the times made for certain distances by professionals in the three kinds of races principally dealt with, will make clearer the discussion following. The lower curve of the chart represents the record for the distances given in the unpaced efforts against time. The middle curve the paced race against time, and the upper curve the best time made in competition races with pacemaker.

The definition of these races may be given as follows: The unpaced race against time is all effort by a single individual to lower the established record. No pacemaker is used; the only stimulation of the rider being the idea of reducing his own or some other man's former time. The paced race against time is also a single effort to make a record. It differs only in the fact that a swift multicycle, such as a tandem or "quod" "makes the pace" for the rider. If he has well trained pacers and is skillful in changing crews as they come on, so as to avoid losing speed, the paced man may reduce the mark for the distance ridden. The two kinds of efforts described are not really races but are called so for convenience. Both are run with a flying start.

The third or paced competition race is a real race. Here, besides keeping up with the

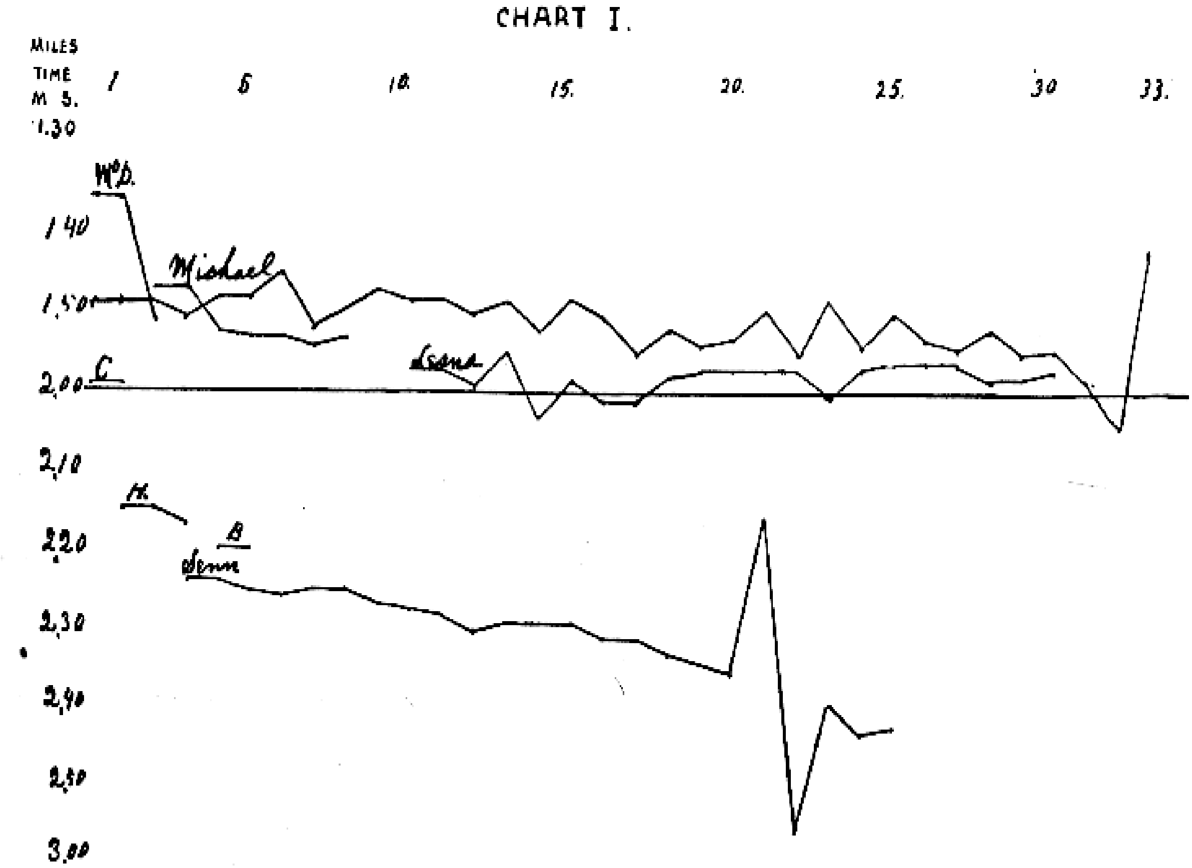
pacemaker, is the added element of beating the other contestants. No records are given for the unpaced competition race. This race will, however, be referred to in the course of this paper. It is often called a "loafing" race from the fact that the riders hang back and [p. 508] try to make pacemakers of each other, well knowing that a contestant starting out to make the pace can not win.

VALUE TO BE GIVEN THESE, RECORDS

In presenting these records it is with the feeling that they have almost the force of a scientific experiment. There are, it is computed, over 2,000 racing wheelmen, all ambitious to make records. The figures as they stand to-day have been evolved from numberless contests, a few men making records which soon fall to some of the host who are pressing closely behind. Reductions now made, however, are in general small in amount. Were all the men engaged in racing to make an effort to reduce the time in the kinds of races named, it is probable that the records already made would stand or be but very little reduced while the present leaders and their closest competitors would again assert their superiority, each in his own style of race. Regarding the faster time of the paced races, as derived from the records, it may be asked whether the difference is due to pacing or to the kind of men who take part; and whether the argument ascribing the difference noted to pacing or competition should have less validity from the fact that different men hold the records in the different races. Men fast at one kind of racing are found to be comparatively slow at another. It is for this reason, perhaps, that Michael refuses to meet any one in an unpaced contest. The racer finds by experience that race in which he is best fitted to excel and specializes in that. The difference in time, therefore, between the paced and unpaced race, as shown by the records, is a measure of the difference between the experts in the two classes of racers. It seems probable that the same amount of difference exists relatively between the averages of the classes they represent. A striking practical proof that the difference between the paced and unpaced trials noted in the records is due to pacing, is found in the paced and unpaced time of some individual racers, given later, in which the difference in time corresponds closely to that of the records. The fact may be mentioned, too, that wheelmen themselves generally regard the value of a pace to be from 20 to 30 seconds in the mile.

DISCUSSION OF RECORDS.

Since the records of unpaced efforts against time, shown on the lower curve of the chart, are given only to 25 miles, comparisons with the other races are made for the same distance. As is readily seen the time made here is much slower than in the paced race against time. The various factors advanced [p. 509]



Lower curve, unpaced—against time. Middle curve, paced—against time. Upper curve, paced competition race.

[p. 510] in explanation are given in detail in the following pages but the fact itself deserves attention at this point.

It has been stated that the value of a pace is believed by racing men to be worth to the racer from 20 to 30 seconds in the mile, depending on the individual. The difference between the paced and unpaced race against time is, it is seen from these figures, somewhat greater.

	Average time per mile. Min.	Sec.	Gain over unpaced. Sec.	Gain per cent. over unpaced.	Gain per cent. competition over paced.
25 miles unpaced against time,	2	29.9			
" " paced " "	1	55.5	34.4	22.9	
" " paced competition,	1	50.35	39.55	26.4	3.5

The paced record from the 3rd to the 10th mile inclusive, is held by Michael. His average gain per mile over Senn, the unpaced champion, is 4 seconds. From the 11th mile upward, a different man, Lensa, holds the paced records. Evidently the pace is not worth so much to him for his average gain per mile is only 29.7 seconds, and a portion of this apparent gain is really due to the increasing exhaustion of the unpaced man, Senn.

That the ability to follow a pace varies with the individual is well known. As a rule the rider who is fast with a pace is slow without it, -- and the converse is believed to be true. This is the reason why the same man can never hold records in both paced and unpaced races. Walter Sanger is one of the fastest unpaced riders on the track, but he can ride only a few seconds better with the very best pacemakers, while Michael, whose ability as a "waiter" is almost marvellous, would fall a comparatively easy victim, his rivals think, in an unpaced race. Success in paced racing presupposes a well trained force of pacers. The last named rider has confessedly enjoyed greater advantages than his competitors in this respect.

The regularity with which he rides is seen in his paced record from 3 to 10 miles. His average rate for these 8 miles was 1 min. 53 sec. with a mean variation of less than 8 second. Other evidences of the constancy of the gain from a pace may be seen through all the records, the time for

20	miles	professional, unpaced is		49 min.	20 sec.
25	"	" paced "		49 "	8.4 "
20	"	amateur, unpaced "		52 "	17 "
25	"	" paced "		51 "	57.2 "
80	"	professional, unpaced "	3 hr.	54 "	53 "
100	"	" paced "	3 "	52 "	14 "

Showing in these cases a gain in favor of the pace of practically 25%. However, ratios between records made by different men, even though they are the product of many riders and entitled to great consideration, have not the absolute certainty [p. 511] that the paced and unpaced time of the same man would have. Data on this point is difficult to obtain, however, as trackmen seldom follow both kinds of racing but specialize in that for which they are best fitted. The best times for one mile of two prominent racers who are good at both games have, however, been secured and are here given.

Arthur Gardiner, one mile,	unpaced,	2 min.	3.8 sec.
" " " "	paced by 2 quods,	1 "	39.6 "
Earle Kiser, " "	unpaced,	2 "	10 "
" " " "	paced,	1 "	42 "

The gain, in the case of the first, of the paced over the unpaced, is 24.2 seconds, nearly 20 per cent. The second gains 28 seconds, nearly 22 per cent., or within nine-tenths of one per cent. of the difference between the official paced and unpaced records made by different men.

Dr. E. B. Turner, F. R. C. S., England, in 1889, began a scientific study of the Physiology of Pacing and Waiting races, lasting over three years. He was a racing man himself and in his investigations made many tests on himself and others. Some figures showing the difference in time made by him at different distances, paced and unpaced, are given. In comparining them with the records of to-day it must be remembered that the wheel then used was heavy and fitted with cushion tires so that the time made in trials is slow as compared with the time made with the modern pneumatic wheel, and in consequence the value of the pace expressed in per cent., appears small. It is seen that as between distances paced and unpaced, his average gain per mile for the different trials varies all the way from 11.8 seconds to 20 seconds.

The upper curve of the chart shows the records made in paced competition races. Here, besides beating the record, the racer is intent-on defeating his rivals. This race is started from the tape and in consequence is slightly slower for the first two or three miles than the time in the paced race against time with flying start. Thereafter the better time made witnesses to the power and lasting effect of the competitive stimulus. For 25 miles the time in this race averages 5.15 seconds per mile, or 3.5 per cent. faster than the paced race against time. From the 3rd to the 10th mile the same man, Michael, [1] holds the record in both races. His time in the competition miles averages over 5 seconds faster than his [p. 512]

Distance in Miles.	Details of Pacing.	Time.		Gains for paced over unpaced trial.		Average gain per mile.	Per cent. gain.	
		Min.	Sec.	Min.	Sec.	Sec.		
1	4 Pacemakers	2	37.6					
1	No "	2	49.4		11.8	11.8	7.	
3	5 "	8	6.6					
3	No "	8	57.8		51.2	17.	9.5	
3	No "	9	7.	1	.4	20.	11.7	
4	1 tandem "	11	31.					
4	No "	12	2.4		.53	13.25	7.33	
5	Several "	14	5.8					
5	" "	13	50.4					
5	No "	15	23.8	1	.18	15.6	8.4	
5	No "	15	37.2	1	31.4	18.25	9.8	
5	Alt. laps "	16	38.4	2	32.6	30.5	15.3	
10	Several "	31	18.4					With tricycle.
10	No "	33	17.2	1	58.8	11.8	6.	
25	Numerous "	71	15.8					
25	Shared "	85	21.8	14	6.	36.	16.5	
25	" "	81	16.4	10	.6	24.		

[p. 513] paced miles against time. The fact that the same racing crews were used in both races suggests that in the latter race they also were responsive to the competition stimulus.

In his treatise on the "Physiology of Waiting and Pacemaking in Speed Competitions," Dr. Turner asserts that the causes operating to produce the differences noted between paced and unpaced races are directly due to the physiological effects of bodily and mental exercise. Stated briefly: the man who in a given distance does the greater amount of muscular work burns up the greater amount of tissue and in consequence his blood is more loaded with waste products and he excretes more urea and uric acid than the man who does a less amount in the same time. This excretion of nitrogenous products as shown by his experiments is directly proportional to the amount of work done. The blood, surcharged with the poisonous matter, benumbs the brain and diminishes its power to direct and stimulate the muscles, and the muscles themselves, bathed by the impure blood, lose largely their contractile power. He asserts further, that phosphoric acid is the principal product of brain work, and that carbonic acid, lactic acid and uric acid are excreted in greater quantities during brain work. Therefore, the man racing under conditions to produce brain worry will be most severely distressed.

The production of phosphoric acid by brain work is, however, in dispute. Some observers have found the phosphates diminished, whilst others have found them present in larger quantities during intellectual labor. As James says it is a hard problem from the fact that the only gauge of the amount is that obtained in excretions which represent other organs as well as the brain. Dr. Turner's tables of results bear him out, however, in the assertion that a less amount of waste matter was excreted on days when little or no exercise was taken, a greater amount when pacers were used, and the greatest amount when he made his own pace.

Basing his position on these physiological facts he states his thesis thus: "Given two men of equal calibre, properly trained and racing on a fair course, it is impossible (bar falls and similar accidents) for one of them to lead, make fast running and win the race; and the easier the track, the lighter and better the machines ridden, and the faster the time of the race the longer the distance by which the one following will win." This is known by every rider and accounts for the "loafing" in unpaced competition races, as no man, unless decidedly superior to his competitors, dares to set the pace. [p. 514]

THEORIES ACCOUNTING FOR THE FASTER TIME OF PACED AND COMPETITION RACES.

Of the seven or eight not wholly distinct theories which have been advanced to account for the faster time made in paced as compared with unpaced competitive races and paced races against time as against unpaced races against time, a number need only be stated very briefly. They are grouped according to their nature and first are given two mechanical theories.

SUCTION THEORY.

Those holding to this as the explanation assert that the vacuum left behind the pacing machine draws the rider following, along with it. Anderson's ride of a mile a minute at Roodhouse, Ill., with the locomotive as pacemaker, is the strongest argument in its favor. Those maintaining this theory believe that the racer paced by a tandem is at a disadvantage as compared with the racerpaced by a quod or a larger machine, as the suction exerted is not so powerful.

THE SHELTER THEORY.

This is closely related to the foregoing. Dr. Turner accepts it as a partial explanation of the aid to be gained from a pace, holding that the pacemaker or the leading competitor serves as a shelter from the wind, and that "a much greater amount of exertion, purely muscular, is required from a man to drive a machine when he is leading than when he is following, on account of the resistance of the air, and the greater the amount of wind blowing the greater the exertion, and conversely, the greater the shelter obtained the less the exertion."

This is the theory held, in general, by racers themselves. One of the champion riders of the country recently expressed this common view in a letter, as follows: "It is true that some very strong unpaced riders do not have any sort of success in paced racing. The only reason I can give for this is just simply that they have not studied the way to follow pace so as to be shielded from the wind. No matter which way it blows there is always a place where the man following pace can be out of the wind."

ENCOURAGEMENT THEORY.

The presence of a friend on the pacing machine to encourage and keep up the spirits of the rider is claimed to be of great help. The mental disposition has been long known to be of importance in racing as in other cases where energy is expended. It is still as true as in Virgil's time that the winners can because they think they can. [p. 515]

THE BRAIN WORRY THEORY.

This theory shows why it is difficult for the leader in an unpaced competition race to win. For "a much greater amount of brain worry is incurred by making the pace than by waiting" (following). The man leading "is in a fidget the whole time whether he is going fast enough to exhaust his adversary; he is full of worry as to when that adversary means to commence his spurt; his nervous system is generally strung up, and at concert pitch, and his muscular and nervous efforts act and react on each other, producing an ever increasing exhaustion, which both dulls the impulse-giving power of the brain and the impulse-receiving or contractile power of the muscles."

THEORY OF HYPNOTIC SUGGESTIONS.

A curious theory, lately advanced, suggests the possibility that the strained attention given to the revolving wheel of the pacing machine in front produces sort of hypnotism and that the accompanying muscular exaltation is the secret of the endurance shown by some long distance riders in paced races. Notice that Michael was able to make the last mile of his great 30 mile competition race the fastest of all and one of the fastest ever ridden.

THE AUTOMATIC THEORY.

This is also a factor which favors the waiting rider, and gives him a marked advantage. The leader, as has been noted, must use his brain to direct every movement of his muscles. As he becomes more distressed it requires a more intense exertion of will power to force his machine through the resisting air. On the other hand, the "waiter" rides automatically. He has nothing to do but hang on. "His brain having inaugurated the movement leaves it to the spinal cord to continue it and only resumes its functions when a change of direction or speed is necessary." --(Lagrange.) When he comes to the final spurt, his brain, assuming control again, imparts to the muscles a winning stimulus, while the continued brain work of the leader has brought great fatigue.

These facts seem to have a large foundation in truth. The lesser amount of fatigue incurred in paced trials is a matter of general knowledge. It is a common experience with wheelmen, and within that of the writer, that when following a lead on a long ride the feeling of automatic action becomes very pronounced, giving the sensation of a strong force pushing from behind. Of course the greater the distance ridden the more apparent becomes the saving in energy from automatic riding, as time is required to establish the movement. It may be remembered, in this connection, that while the average gain [p. 516] of the paced over the unpaced record is 34.4 seconds, the difference between them for the first mile is only 23.8 seconds.

As between the pacer and the paced, every advantage seems to rest with the latter. The two mechanical factors of suction and shelter, so far as they are involved, assist the rider who follows. So the psychological theories, the stimulation from encouragement, the peculiar power induced by hypnotism, and the staying qualities of automatic action, if of help at all, directly benefit the paced rider. The element of disadvantage induced by brain action, on the contrary, belongs more especially to the rider who leads.

THE DYNAMOGENIC FACTORS.

The remaining factors to be discussed are those which the experiments on competition, detailed in the second part hereof, attempt to explain. No effort is made to weaken the force of the foregoing factors in accounting for the better time of paced races in comparison with unpaced races of the same type, but the facts of this study are given to throw whatever additional light they may.

This theory of competition holds that the bodily presence of another rider is a stimulus to the racer in arousing the competitive instinct; that another can thus be the means of releasing or freeing nervous energy for him that he cannot of himself release; and, further, that the sight of movement in that other by perhaps suggesting a higher rate of speed, is also an inspiration to greater effort. These are the factors that had their counterpart in the experimental study following; and it is along these lines that the facts determined are to find their interpretation.

OTHER FORMS OF RACING.

A few brief statements, mostly quoted from Dr. Turner's treatise, are given to show the value of a pacemaker in other forms of racing: "Foot racing differs from cycle racing in that it involves a much greater muscular effort. At each stride the whole body must be lifted and projected seven feet or more. The exertion is much the same whether the competitor makes his own pace or follows." So the "leader" and "waiter" commence their final spurt under more equal conditions than those which obtain in a cycle race, and a much smaller degree of superiority in the leading man enables him to run the spurt out of his opponent and win.

In ice skating the conditions are closely similar to those in wheel races, and a pacemaker is of nearly as much use as On the cycle track.

In a boat race the crews do not wait behind each other, but [p. 517] struggle for the lead, and when they have obtained it "wait in front." The reasons for this are good:

(1) If a boat be clear in front it may take its opponent's water and wash it.

(2) The crew leading can see the others and regulate its pace accordingly.

(3) The actual physical labor involved in propelling a boat is very great, and therefore the laws of exercise already treated of apply.

(4) The length of a racing eight is 50 feet or more, and the time necessary to pass is too great to permit of waiting.

For similar reasons there is not the slightest advantage in waiting in a swimming race.

In horse racing a pacemaker is of use, but is not the overwhelming advantage it is in cycle racing. A good horse can run out an inferior, just as a good man can on foot; but in big races a stable companion is generally started to make running, when the favorite is a good stayer, in order that he may have a fast run race, without being put to the disadvantage of him self making the pace. This is especially true of distance races.

Kolb, from his study of the respiration and pulse curves resulting from a maximum effort in the various kinds of races, asserts that in cycling and skating, where great speed is attained by the use of special groups of muscles, it is the pulse rate that is largely increased, while in boat racing, running, wrestling and heavy gymnastics, the respiration is chiefly affected. If this claim is established it may furnish a reason why the pacemaker or competitor has greatest value in cycle and skating races. In these, where the ratio between power and speed is high, the outflow of nervous energy necessary in spurting has large expression. In the other class, while the energy made available by the competitive instinct, is probably the same, it is limited in its results by the respiratory need.

PART II.

From the laboratory competitions to be described, abstraction was made of nearly all the forces above outlined. In the 40 seconds the average trial lasted, no shelter from the wind was required, nor was any suction exerted, the only brain worry incident was that of maintaining a sufficiently high rate of speed to defeat the competitors. From the shortness of the time and nature of the case, generally, it is doubtful if any automatic movements could be established. On the other hand, the effort was intensely voluntary. It may be likened to the 100 yard dash a sprint from beginning to end. [p. 518]

DESCRIPTION OF APPARATUS.

The apparatus for this study consisted of two fishing reels whose cranks turned in circles of one and three-fourths inches diameter. These were arranged on a Y shaped frame work clamped to the top of a heavy table, as shown in the cut. The sides of this frame work were spread sufficiently far apart to permit of two persons turning side by side. Bands of twisted silk cord ran over the well lacquered axes of the reels and were supported at C and D, two meters distant, by two small pulleys. The records were taken from the course A D. The other course B C being used merely for pacing or competition purposes. The wheel on the side from which the records were taken communicated the movement made to a recorder, the stylus of which traced a curve on the drum of a kymograph. The direction of this curve corresponded to the rate of turning, as the greater the speed the shorter and straighter the resulting line.

METHOD OF CONDUCTING THE EXPERIMENT.

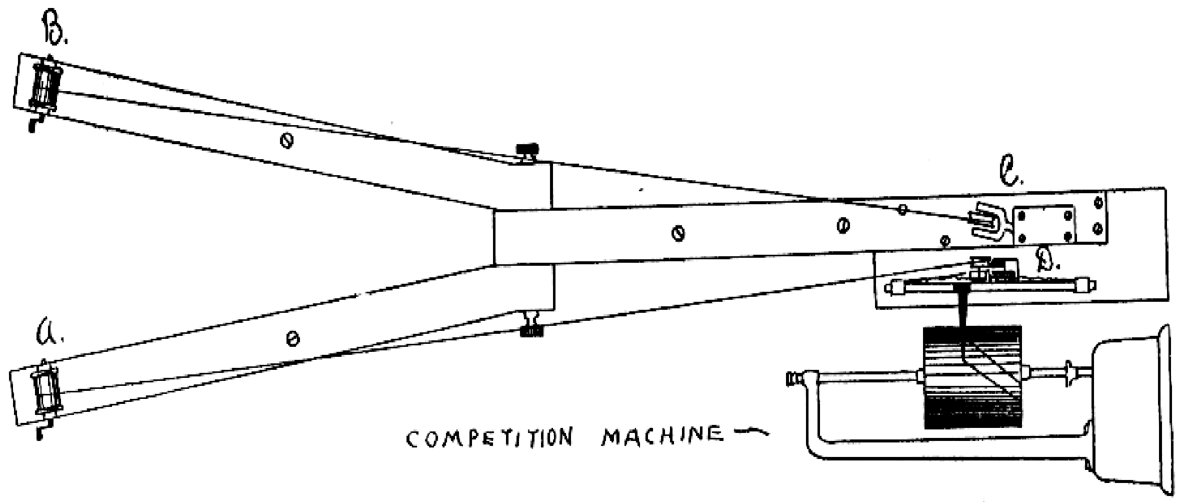
A subject taking the experiment was required to practice turning the reel until he had become accustomed to the machine. After a short period of rest the different trials were made with five-minute intervals between to obviate the possible effects of fatigue.

A trial consisted in turning the reel at the highest rate of speed until a small flag sewed to the silk band had made four circuits of the four-meter course. The time of the trial was taken by means of a stop-watch. The direction of the curves made on the drum likewise furnished graphic indications of the difference in time made between trials.

LIMITS OF ERROR.

Frequent trials of the machinery showed very small errors. In each regular trial the flag travelled 16 meters. For ten test trials the average number of turns of the reel necessary to send it over this course was found to be 149.87, with a mean variation of .15, showing that the silk band did not slip to any appreciable extent. If 40 seconds be taken as the average time of a trial (which is not far wrong), .15 of a turn will be made in .04 second.

Care was also exercised to have the kymograph maintain, so far as possible, a uniform rate of turning. When fully wound up it would run for nearly three hours. The actual running time in taking the six trials of a subject was about 4 minutes, or 40 seconds per trial. In testing, the drum was rotated during 4 minutes. The time necessary to repeat this amount of rotation was found, by trials, to be 4 minutes and [p. 519]



[p. 520] 3 seconds, thus showing a retardation in each trial of about one-eightieth of the former trial as shown on the drum. The direct time of trials was taken with a stop-watch. It is from records thus taken that the tables given are composed. The drum curves, however, are important as giving a graphic representation of whatever changes occurred during the progress of the trial. The stylus, responding immediately to every change in rate of turning, gives clearly: indications of the force of competition, of the effects of adverse stimulation, fatigue, and other phenomena. The tendency of the retardation of the drum would be to diminish all these effects by one-eightieth an amount not appreciable to the eye.

STATEMENT OF RESULTS.

In the course of the work the records of nearly 225 persons of all ages were taken. However, all the tables given below, and all statements made, unless otherwise specified, are based on the records of 40 children taken in the following manner: After the usual preliminaries of practice, six trials were made by each of 20 subjects in this order: first a trial alone, followed by a trial in competition, then another alone, and thus alternating through the six efforts, giving three trials alone and three in competition. Six trials were taken by 20 other children of about the same age, the order of trials in this case being the first trial alone, second alone, third a competition trial, fourth alone, fifth a competition, and sixth alone.

By this scheme, a trial of either sort, after the first one, by either of the two groups, always corresponds to a different trial by the opposite group. Further, when the subjects of the two groups come to their fourth and sixth trials, an equal amount of practice has been gained by an equal number of trials of the same kind. This fact should be remembered in any observation of the time made in trials by any group.

During the taking of the records, and afterwards in working them over, it was seen that all cases would fall into two classes:

First. Those stimulated --

1. to make faster time in competition trials,

2. in such a way as to inhibit motion.

Second. The small number who seemed little affected by the race.

The three tables which follow are made up from the records of the 40 subjects mentioned. The classification was in general determined by the time record as taken by the watch.

The first table gives the records of 20 subjects who, on the whole, were stimulated positively. The second table contains 10 records of subjects who were overstimulated. The third table shows the time of 10 subjects who give slight evidence of being stimulated. [p. 521]

The probable error used in the tables is that for a single observation: $r = .6745 \sqrt{\frac{\Sigma v^2}{n-1}}.$ Its magnitude is large from the nature of the case. To ascertain how large this should properly be, the individual differences of the subjects of Group A in Table I were eliminated in the following manner: The average of the six trials made by each subject was taken as most fairly representing him. With this as a basis the six trials were reduced to percentages-thus doing away with peculiarities due to age and disposition. By this means the probable errors of this group for the six trials in order were 2.57, 1.43, 1.81, 2.24, 1.11, 1.55. A similar reduction should be made in the probable error of all the tables.

In the tables, A represents a trial alone, C a trial in competition.

TABLE I.

Subjects Stimulated Positively.

GROUP A.

	Age.	A.	C.	A.	C.	A.	C.
Violet F.	10	54.4	42.6	45.2	41.	42.	46.
Anna P.	9	67.	57.	55.4	50.4	49.	44.8
Willie H.	12	37.8	38.8	43.	39.	37.2	33.4
Bessie V.	11	46.2	41.	39.	30.2	33.6	32.4
Howard C.	11	42.	36.4	39.	41.	37.8	34.
Mary M.	11	48.	44.8	52.	44.6	43.8	40.
Lois P.	11	53.	45.6	44.	40.	40.6	35.8
Inez K.	13	37.	35.	35.8	34.	34.	32.6
Harvey L.	9	49.	42.6	39.6	37.6	36.	35.
Lora F.	11	40.4	35.	33.	35.	30.2	29.
Average	11	47.48	41.88	42.6	39.28	38.42	36.3
P. E.		6.18	4.45	4.68	3.83	3.74	3.74
Gains			5.6	.72	3.32	.86	2.12

GROUP B.

	Age.	A.	A.	C.	A.	C.	A.
Stephen M.	13	51.2	50.	43.	41.8	39.8	41.2*
Mary W.	13	56.	53.	45.8	49.4	45.	43.*
Bertha A.	10	56.2	49.	48.	46.8	41.4	44.4
Clara L.	8	52.	44.	46.	45.6	44.	45.2
Helen M.	10	45.	45.6	35.8	46.2	40.	40.
Gracie W.	12	56.6	50.	42.	39.	40.2	41.4
Dona R.	15	34.	37.2	36.	41.4	37.	32.8
Pearl C.	13	43.	43.	40.	40.6	33.8	35.
Clyde G.	13	36.	35.	32.4	33.	31.	35.
Lucile W.	10	52.	50.	43.	44.	38.2	40.2
Average	11.7	48.2	45.68	41.2	42.78	39.	39.82
P. E.		5.6	4.	3.42	3.17	2.89	2.84
Gains			2.52	4.48	1.58	3.78	.82

* Left-handed.

TABLE II.

Subjects Stimulated Adversely.

GROUP A.

	Age.	A.	C.	A.	C.	A.	C.
Jack R.	9	44.2	44.	41.8	48.	44.2	41.
Helen F.	9	44.	51.	43.8	44.	43.	41.2
Emma P.	11	38.4	42.	37.	39.6	36.6	32.
Warner J.	11	41.6	43.6	43.4	43.	40.	38.
Genevieve M.	12	36.	36.	32.6	32.8	31.2	34.8
Average	10.4	40.84	43.32	39.72	41.48	39.	37.4
P. E.		2.41	3.57	3.25	3.85	3.55	2.52

GROUP B.

	Age.	A.	A.	C.	A.	C.	A.
Hazel M.	11	38.	35.8	38.2	37.2	35.	42.
George B.	12	39.2	36.	37.6	34.2	36.	33.8
Mary B.	11	50.	46.	43.4	42.	48.	36.8
Carlisle B.	14	37.	35.4	35.	33.4	36.4	31.4
Eddie H.	11	31.2	29.2	27.6	27.	26.8	28.8
Average	11.8	39.08	36.48	36.36	34.76	34.4	34.56
P. E.		4.61	4.07	3.89	3.71	5.33	3.45

TABLE III.

Subjects little affected by competition.

GROUP A.

	Age.	A.	C.	A.	C.	A.	C.
Albert P.	13	29.	28.	27.	29.	27.	28.6
Milfred V.	17	36.4	29.	29.4	30.2	30.2	32.2
Harry V.	12	32.	32.	32.6	32.6	32.6	31.6
Robt. H.	12	31.4	31.4	32.2	35.4	35.	32.4
John T.	11	30.2	30.8	32.8	30.6	32.8	31.8
Average	13	31.8	30.24	30.8	31.56	31.5	31.3
P. E.		1.9	1.13	1.71	1.7	2.06	1.05

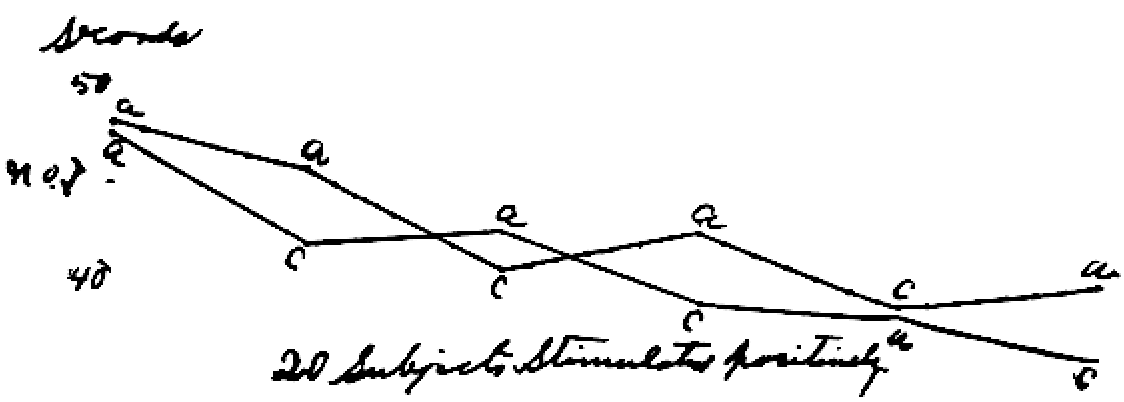
GROUP B.

	Age.	A.	A.	C.	A.	C.	A.
Lela T.	10	45.	37.4	36.8	36.	37.2	38.
Lura L.	11	42.	39.	38.	37.	37.	38.
Mollie A.	13	38.	30.	28.	30.	30.2	29.6
Anna F.	11	35.	31.8	32.4	30.	32.	30.4
Ora R.	14	37.2	30.	29.	27.8	28.4	26.8
Average	11.8	39.44	33.64	32.84	32.16	32.96	32.16
P. E.		3.11	2.88	3.03	2.75	2.69	3.71

[p .523] The 20 subjects given in Group A and Group B, of Table I, in nearly all cases make marked reductions in the competition trials. The averages show large gains in these trials and small gains or even losses for the succeeding trials alone. The second trial for Group A is a competition, for Group B a trial alone. The gain between the first and second trials of the first group is 5.6 seconds, between the first and second trials of the second group, 2.52 seconds. The latter represents the practice effect -- always greatest in the first trials, the former the element of competition plus the practice. The third trial in Group A -- a trial alone -- is .72 seconds slower than the preceding race trial. The third trial in Group B -- a competition -- is 4.48 seconds faster than the preceding trial alone. The fourth trials in these two groups are on an equality, as regards practice, from an equal number of trials of the same kind. In the first case the gain over the preceding trial is 3.32 seconds. In the latter there is a loss of 1.58 seconds from the time of the preceding competition trial. In like manner there is an equality of conditions in regard to the sixth trial of these groups, and again the effect of competition plainly appears, the competition trial gaining 2.12 seconds, and the trial alone losing .82 seconds with respect to the preceding trial. These are decided differences. Curve No. 1 in Chart II is a graphical representation of them.

The 10 subjects whose records are given in Table II are of interest. With them stimulation brought a loss of control. In one or more of the competition trials of each subject in this group the time is very much slower than that made in the preceding trial alone. Most frequently this is true of the first trial in competition, but with some was characteristic of every race. In all, 14 of the 25 races run by this group were equal or slower than the preceding trial alone. This seems to be brought about in large measure by the mental attitude of the subject. An intense desire to win, for instance, often resulting in over-stimulation. Accompanying phenomena were labored breathing, flushed faces and a stiffening or contraction of the muscles of the arm. A number of young children of from 5 to 9 years, not included in our group of 40, exhibited the phenomena most strikingly, the rigidity of the arm preventing free movement and in some cases resulting in an almost total inhibition of movement. The effort to continue turning in these cases was by a swaying of the whole body.

This seems a most interesting fact and confirmatory of the probable order of development of the muscles as given by Dr. Hall and others. In the case of those sufficiently developed to have the fast forearm movement, fatigue or overstimulation seemed to bring a recurrence to the whole arm and shoulder [p. 524]



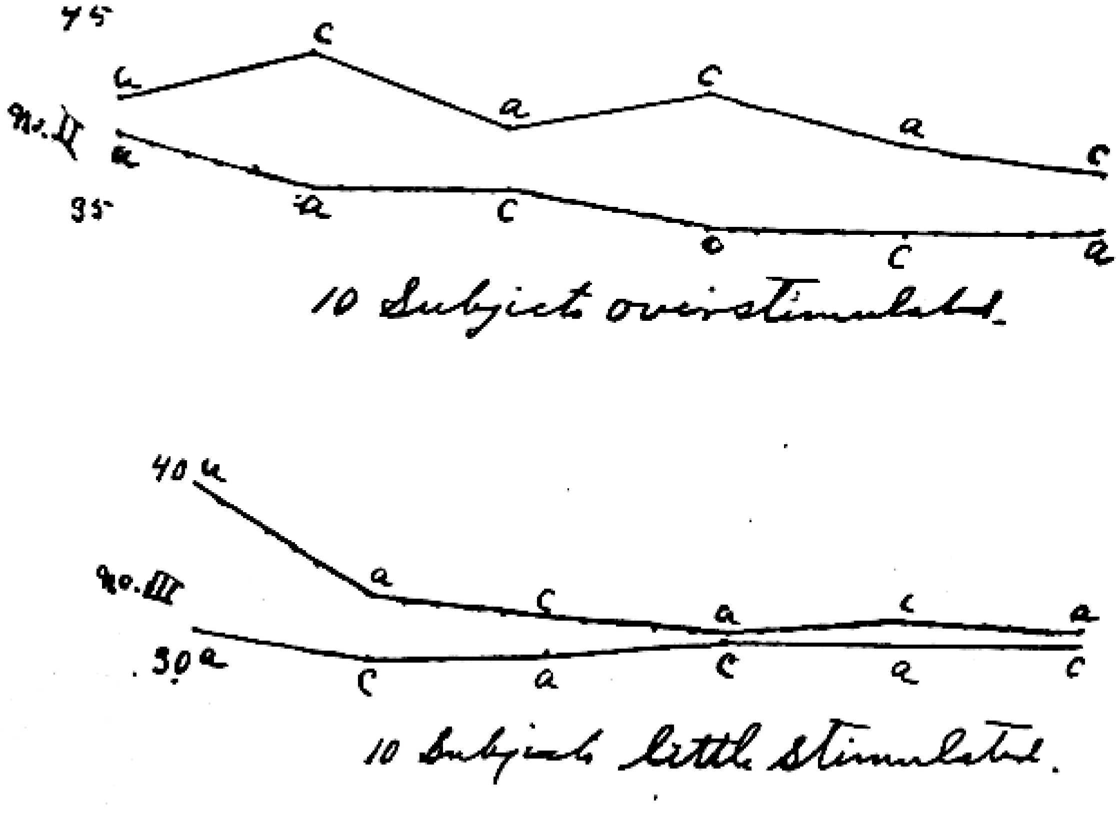


Chart II Solid line represents group A.
Dotted " " " B.

movement of early childhood, and if the fatigue or excitement was sufficiently intense, to the whole body movement, while younger children easily fell into the swaying movement when affected by either of the causes named.

It reminds one of the way in which fatigue of a small muscle used in ergographic work, will cause the subject to attempt to draw on his larger muscles, or, of the man who moves to [p. 525] the city and acquires the upright carriage and springing step of the city-bred man, who, when greatly fatigued, insensibly falls into the old "clodhopper" gait. This tendency to revert to earlier movements and also old manners of speech, as Höpfner has shown in his "Fatigue of School Children," is common, when, for any reason, the centers of control are interfered with. It may be said, therefore, that in the work under consideration the chief difference between this group and the large group in Table I, was a difference in control; the stimulation inhibiting the proper function of the motor centers in the one case, and reinforcing it in the other. This, at least, seemed apparent from the characteristics exhibited by the two classes. Observation of the subjects of this class under trial, and careful scrutiny of their graphic records, show how decided gains were sometimes lost by the subject "going to pieces" at the critical point of the race, not being able to endure the nervous strain. Yet there exists no sharp line of division between subjects stimulated to make faster time and those affected in the opposite way. In some instances the nervous excitement acted adversely in every race trial, while in others, a gain in control, enabled the subject to make a material reduction in the last competition. A. B., one of three adults affected adversely, is an athletic young man, a fine tennis and hand-ball player, and known to be stimulated in contests of these kinds. It was noticed that in his competition trials time was lost because of his attempt to take advantage of the larger muscles of the arm and shoulder. After many trials and injunctions to avoid the movement he gained sufficient control to enable him to reduce the time in the competitions.

A. V., an adult of nervous organization, went half through his race with a great gain over his trial alone, but seeing his antagonist pushing him closely, broke down and lost the most of the gain made in the first half. The time of the trial alone was 38.6 seconds, that of the competition was 37.2 seconds. A comparison of the time in which the halves of the trials were made was computed in the following way: On the ordinate of the graph is measured the distance the stylus travels across the drum during 150 turns of the reel -- the number in a trial. The distance on the abscissa between the ordinates running through the ends of the curve of any trial gives the time of the trial.

Parallel abscissas were drawn at the extremities of the curves, and a third one-half way between them. Half of the turns made in a trial were thus on each side of this middle line, and the times in which these turns were mode were proportional to the segments of this line made by the curve intersecting it. By this means it was found that A. V. made the first [p. 526] 75 turns in his competition trial in 15 seconds, the second half in 22.2 seconds. By the same means, each half of the preceding trial alone was 19.3 seconds -- an exception to the rule that the last half is slower because of fatigue.

Other curves when worked out in this way gave similar results. The time record, therefore, it must be seen, is not always a true index to the amount of stimulation present. Had the trials consisted of but half as many turns the effect of competition as it appears in the tables would have been shown much more constantly. Table II mould have been a smaller group if indeed any necessity existed for retaining it.

A comparison of the time made by the different groups shows that the subjects of Table I are much slower than those of Table II, and that a still greater difference exists between this group and the subjects found in Table III. It may be said that they are slower because of greater sluggishness of disposition, and that the reductions made are largely a result of the subjects warming up. This, indeed, may be a part of the cause for it, but as the larger reductions coincide with the competition trials this cannot be held to completely account for it. A glance over the individual records discovers some facts which furnish a plausible partial explanation, when taken in connection with the following fact. The age at which children acquire control of the wrist movements, a large factor in turning the reel with speed, was found to be about 11 years in general, although a few of 9 and 10 years had this power. Now, of the 20 subjects composing Table I, 7 are 10 years of age or younger, while two others, age 13, are left-handed and being compelled to use the right hand are slow in consequence. So, here are 9 subjects, a number nearly equal to the group in Table II or Table III, who had a reason for being slow. Were these omitted from the count, the time of the initial trial would be found not to vary materially from that of Table II.

Besides the lack of muscular development of the younger subjects mentioned above, many of the subjects of Table I seemed not to have proper ideals of speed. The desire to beat, if it did nothing else, brought them to a sense of what was possible for them. The arousal of their competitive instincts and the idea of a faster movement, perhaps, in the contestant, induced greater concentration of energy.

The subjects in Table III, are a small group who seemed very little affected by competition. They made very fast time, but they are older than the average; their muscular control was good, and they had the forearm movements. Practice gains while somewhat apparent at first in some cases, are, as shown by curve NO. 3 of the chart, on the whole, less in amount. [p. 527]

Their drum records show fewer fluctuations and irregularities, and less pronounced fatigue curves at the end.

There seems to be a striking analogy between these subjects and those racing men who are fast without a pace, but can do little or no better in a paced or competition race.

OBSERVATIONS ON THE WORK.

Energy Fluctuations. Among the many personal differences shown by the various subjects, nervous peculiarities were of great interest. A number exhibited the marked periodicity of energy discovered by Dr. Lombard, and described by him in the AMERICAN JOURNAL OF PSYCHOLOGY. It was especially prominent in the cases of L. P. and H. F., both bright children of an exceedingly nervous temperament, a rapid period being succeeded by one of apparent fatigue, thus alternating to the end of the trial. It was noticeable both in trials alone and in competition. In both subjects the phenomenon became less marked in the course of the trials. Both were much affected by the stimulation. The first making gains in her races, the second, almost helpless from nervous agitation in her first competition, does better in the second, and succeeds in making a substantial reduction in her third race, although a large part of the gain made in the first half of the trial is lost in the second.

Kolb in his "Physiology of Sport" asserts that in every physical contest involving a maximum effort there will be fluctuations of energy, and says that all oarsmen are familiar with the "hills" in the boat race, one being encountered in the second minutes the other at the end of the sixth minute. Long distance runners also experience the ebb and flow of strength markedly.

Effects from Age. It seems probable that one who is amenable to the stimulation of competition in childhood win be susceptible during his whole life; like the race horse that retains his desire to run long after the ability is lacking. The age at which the instinct develops was not ascertained. Two boys of 5 years possessed it to a marked degree. The one defeated in their race, according to his mother, felt badly about it all day. Adult subjects displayed the same differences of stimulation as in the case of children. It might be inferred from the records taken that the effect is greatest in early life and diminishes with advancing years. The practice effect, however, is greatest among the young, as they do not have the skill in the use of the hand that comes later. With adults, owing to their greater muscular control, practice counts for much less. So it was that the latter more surely made reductions in their competition trials, but smaller ones. [p. 528]

People differ greatly, as was noted, in the degree in which they are stimulated, but for the same individual it seems to be a constant force.

Two girls who were trained till the gain from practice was a small matter, in a ten days trial showed remarkable uniformity in making reductions in their race trials. From the shortness of the period, in these cases, half the usual number of turns, and the skill acquired, the reductions were, however, small in amount. The average for the ten days are as follows:

	a	c	a	c	a	c
Bessie V.	15.8	14.9	15.3	14.65	15.3	14.55
Helen F.	18.45	17.75	18.52	17.22	18.02	16.77

Each subject had 30 competitions. Out of this number the time for the first subject was reduced in 24 or four-fifths of the entire number. It was equal to the preceding trial in two cases. The second was faster in her race trials in 25 of the 30 or five-sixths of all, and in two cases equalled the preceding record. Of the three remaining trials, the pain from a blister on the hand caused one to be made in slower time.

In the race trials of the 40 subjects a portion of the reduction when made might in some cases be attributed to encouraging remarks. For instance, the racer would be told to "keep on, you are ahead," or "just one more round," in order to steady him. In the extended trial of the two subjects under discussion, however, some preliminary words to arouse the desire to beat were used, but after the start not a word was spoken. Whatever effect appeared was purely that of competition.

SEX DIFFERENCES.

Some small differences were found in the motor rate between the sexes, corresponding in general to the results exhibited in Dr. W. L. Bryan's study of "Motor Ability." For this grouping, the averages only for which are given, all cases were taken in which a trial alone was succeeded by a trial in competition.

At 10 years of age the boys begin faster than the girls, but both sexes are practically together on the competition trial. The greater speed of the boys, as Dr. Bryan has pointed out, is largely a result of their greater knack or skill in doing things, attributable to their more active life.

At 11 the boys are distinctly ahead, and, as noted before, a year's time has brought a large increase in speed, as at about this age a free use of the wrist movement is gained. At 12 the boys are slower than at 11, and have no advantage over the [p. 529]

With this table the mean variation was used.

TABLE IV.

Age.	Males.			Females		
	Cases.	A.	C.	Cases.	A.	C.
10	5	41.88	41.6	13	46.83	41.4
		4.34	5.52		3.76	2.98
11	14	35.76	34.36	25	40.3	37.89
		4.37	5.1		5.2	4.47
12	14	38.1	35.7	19	38.39	35.77
		3.92	2.75		6.11	4.
13	7	34.1	32.94	15	39.65	36.24
		7.13	4.81		5.3	5.1
Adults	45	31.35	29.	14	32.77	29.24
		3.17	3.29		2.8	2.56

girls. A difference appears again at 13 in favor of the boys. In the case of adults a slight margin of difference on the side of the males is seen.

As to the amount of stimulation the odds are apparently with the female sex. The proportion of girls influenced by competition is greater. Of the 40 subjects, 14 or 36.6 per cent. were boys, 26 or 63.4 per cent. were girls. In the group of those who were susceptible and influenced positively were 28.6 per cent. of the boys and 61. 5 per cent. of the girls. In the group influenced negatively were 35.7 per cent. of the boys and 19.2 per cent. of the girls, and in the group not influenced 35.7 per cent. of the boys and 19.2 per cent. of the girls were found. These figures are deduced from the grouping made on the basis of the time record. An inspection of the graphs indicates that six in Table III were somewhat stimulated, although it is not made evident from the watch record. Were these subjects, consisting of 5 girls and 1 boy, to be transferred to their proper table the result would show that 100 per cent. of the girls and 71 per cent. of the boys showed stimulation.

The gross amount of the effect of competition is also greater in girls. When they were stimulated and had control they made greater gains than the boys and when over-stimulated their losses were greater than those made by the boys. The 16 girls of Table I gained the average sum of 10 seconds in their competition trials, while the four boys of this group gained an average sum of 8.15 seconds. In Table II the 5 girls lost 3 seconds each, in the course of their competition trials, while the 5 boys lost less than 1 second each.

INFLUENCES AFFECTING THE TIME OF SUCCEEDING TRIALS ALONE

It is a well-known fact, that some wheelmen, who in private practice can go very fast, fail to distinguish themselves when [p. 530] the real race is run in the presence of the public. The weakening effect of nervous agitation has been ascribed as the cause. On the other hand, Manouvrier, in his dynamometric studies found that this subject increased the energy of his movement when spectators were present. This is a common observation. The boy can turn better handsprings when wishing to impress the girls with a sense of his accomplishments. The football team play better ball under the stimulation of the home crowd. Other examples could be instanced showing how people respond to various social stimulations.

In the records of the 40 subjects found in the three groups discussed above, there are 80 cases wherein a competition trial is followed by a trial alone. Of these, 45 were made in faster time than the preceding competition trial. Several facts seem to contribute to this result.

First, greater facility in turning naturally follows from the practice gained in former trials. In general, spectators were not permitted during the trials alone, but in a few cases visitors were present. The effect of this would be to stimulate the subject in a trial alone. Then, too, the competition element entered into the trials alone and it was found advisable in some cases to keep from the subject the time made, as there was a constant desire to beat his own or his friend's records, and thus make all the trials competitive. The competition feeling seemed present at the time. It is felt, therefore, that succeeding trials alone are not really non-competitive trials.

In addition, the competition trial was a pattern for after trials, giving a higher ideal of speed and a hint of what was possible for the subject. Féré remarks that it was his own experience, and that of a majority of experimenters in dynamometrie, "that the second trial was in general stronger than the first, the first trial having the effect of reinforcing the idea of the movement." The same thing seems peculiarly true of the kind of work under discussion. The subject comes to a succeeding trial alone with a reinforced image of the movement. The over-excitement of the former race is gone, but somewhat of its stimulating effect, it may be, remains and in consequence more than half of the cases equal or exceed the former competitive trial. [p. 531]

PART III.

THE IDEA OF MOVEMENT.

We are led to believe that in all the laboratory competitions detailed in Part II of this article, besides the bodily presence of a competitor, the idea of his movement, whether gained from sight or sound, had a stimulating effect on the racer. Some subjects followed with the eyes the course of the flags during the race and directed their exertions accordingly. Others seemed to be spurred on by the sound of the other machine, gaining some idea of the speed from the noise it made. Either seemed to possess equal power as a stimulus.

A favorite psychological principle with Féré, whose "Sensation of Mouvement" describes the most important work done in the field of Dynamogeny, is that "the energy of a movement is in proportion to the idea of that movement." He gives an experiment illustrating the subject as follows :
" If we ask the subject to look attentively at the movements of flexion, which we make with our hand, at the end of a few minutes he declares that he has the sensation of the same movement being made in his own hand, even though it may be entirely unmoved. And soon, indeed, his hand begins irresistibly to execute rhythmic movements of flexion. Or, if instead of letting the experiment come to this point, the subject is stopped at the moment where he commences to have the sensation of movement, and a dynamometer is placed in his hand, it is shown that the energy of his effort is increased one-fourth to one-half." Before the experiment the normal dynamometric force of the right hand was 23 kg., of the left, 15 kg. After seeing the experimenter make 20 flexions, the pressure for the subject's right hand was 46 kg., or double the former record. The left hand showed a slightly diminished force. An attempt was made to verify Fere's work with the ergograph. The subject was required to make maximum finger lifts corresponding to the beats of a metronome. After a series of lifts, the signal was given by the

operator raising the index finger as if with the effort of lifting. Of 12 subjects tried, 8 made an increase when taking the time from the finger. The amount of increase seemed to be in proportion to the attention bestowed on the lifted finger of the operator. Two, who noticeably gave little attention to the straining of the finger except as a mere signal for lifting, made no gain whatever. Five maximum lifts of E. J., immediately preceding the substitution of the finger movement, averaged 17.2 millimeters in height, with a mean variation of .6 m.m. The first five efforts made at the sight of the finger movement averaged 19.1 m.m., mean variation .7 m.m., a [p. 532] gain of 11 per cent. P. M. G., towards the end of an exhaustion curve, of which the last five lifts averaged 7.2 m. m., made five lifts, taking the cue from the finger, of an average height of 11.4 m. m., after which the energy of his efforts again began to decrease.

EFFECT OF A HIGHER RATE ON COUNTING.

An experiment on vocalization was made wherein a higher rate was suggested to the subject.

Ten subjects took the work described below on six successive days. Each was required to count aloud from 1 to 20 and repeat, as rapidly as articulation permitted, for 5 seconds. Three trials were made. The operator now counted at a faster rate and asked the subject to follow that rate. Three trials of this kind were made. This may be called Programme A.

Programme B differed from this merely in the one particular that, the operator did no counting, but the three preliminary trials alone were followed instead by three similar trials alone-the intervals between trials, however, remaining the same.

Five subjects began with Programme A and five with Programme B, alternating each day, so that in the course of the six days each person had three experiences with each programme. The average sum counted by each subject during the series of trials is given below. Dividing by nine will give the average number counted in a single trial of that kind.

Programme A.				Programme B.		
Cases.	No. alone.	After a higher rate is given.	Gain.	No. alone.	Alone. No rate given.	Gain.
10	288.4	307.6	19.2	287.	288.5	1.5

The difference between the averages of the first two columns, 19.2, is the average gain of the ten subjects after they have had given them the idea of a faster rate of counting. Under this programme each individual makes a gain, under the other, where no higher rate is given, seven make smaller gains, three lose, and the average gain is but 1.5.

The principle of ideomotor action has wide application in human life. In the cases cited the observance of motion in another became a stimulus to greater effort. It may, however, have the opposite effect. A correspondence of rhythm of movement seems necessary to make it of aid. Two boys jumping together, or one following immediately at the sight of the other's jump, will not cover the distance possible in [p. 533] jumping alone, because the swaying of the body, and swinging of the arms, not being synchronous or rhythmic become a distraction. So one becomes fatigued when walking with a person out of step.

CONCLUDING STATEMENT

From the above facts regarding the laboratory races we infer that the bodily presence of another contestant participating simultaneously in the race serves to liberate latent energy not ordinarily available. This inference is further justified by the difference in time between the paced competition races and the paced races against time, amounting to an average of 5.15 seconds per mile up to 25 miles. The factors of shelter from the mind, encouragement, brain worry, hypnotic suggestion, and automatic movement, are common to both, while the competitors participate simultaneously in person only in the first.

In the next place the sight of the movements of the pacemakers or leading competitors, and the idea of higher speed, furnished by this or some other means, are probably in themselves dynamogenic factors of some consequence.

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[1] Since this article was written Michael's time in paced competition racing has been lowered. On June 17,1898, E. A. McDuffie in his race with Taylor broke all records up to 30 miles. His time was 55:09 1-5, which is 1 min. 23 4-5 seconds faster than Michael's time for that distance. This increases the gain over the paced race against time to 8 seconds per mile.