The Effect of Steadiness Testing On the Variability Of Respiration

by

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Introduction

Certain facts relative to the physiological changes which occur during states of attention have become fairly well established in psychology. It is known, for instance, that in close visual attention there is a tension of the skeletal muscles; a fixation of the eyes, with dilation of the pupils and secretion of tears; changes in the blood pressure and heart rate, and changes in respiration. During periods of auditory attention, respiration is characteristically retarded in rate and becomes more irregular in amplitude, the reason given being that the respiratory movements in auditory attention, and possibly their sound as the air passes through the nares, form a distracting influence.[1] In situations involving precision of muscular coordination, respiratory movements are altered because these movements disturb the adjustment to be made. In firing a gun, Gaskell reports,[2] a deep breath is taken, exhaled slightly, and then held while the trigger is pulled in order that movements incident to breathing will not disturb the gun.

Billing and Sheppard have made a study of the changes in heart rate and breathing due to visual and auditory attention.

1. Billing and Sheppard, Psych. Rev., 1910, 17, P. 227.
2. Gaskell, J. Exper. Psychol., 1928, 11, P. 364.

Respiration, they report, is affected in both rate and amplitude by such attention on the part of the subject. Deep breathing and its movements interfere with visual acuity, and rapid breathing interferes with the keeness of hearing.[1] There is no report in the available literature of the influence upon the regularity of rate and amplitude of breathing during tests for steadiness.

This study is an attempt to discover any characteristics of respiration which accompany an act involving precision of motor control and a general condition of postural tension. Such a condition is observable in the efforts of a subject to hold a stylus in the smallest hole of a 9 hole Stoelting steadiness tester without making contacts. I was particularly concerned with the degree of irregularity of respiration.[2]

1. Billing and Sheppard, Op. Cit., P. 227
2. Note on the nervous mechanism of respiration:

   The respiratory nervous center has been assigned to the caudal part of the medulla. It is sensitive to changes in the carbon dioxide content of the blood. This accounts for the rhythm of normal respiration since efferent fibers from this center supply the intercostals, and the diaphragm through the tractus solitarus, and the lungs through the sympathetic branches of the vagus. (Ranson) Due to the fact, however, that the muscles ennervated from the respiratory center are somatic, the respiratory rhythm is subject to great variation as the result of voluntary control. In this study the decided reduction in variability of respiration as well as the typical reduction in amplitude are probably due to impulses from higher centers to the somatic musculature which prevents their normal rhythmic contraction. The deep sigh of relief is due to a persistent accumulation of CO_2 during the period of reduced respiration, resulting in the compensatory inspiration at the end of the test.

In other words, the average height of the respiratory tracings during the stimulus period might be less than one half the amplitude of the waves during the preceding normal period, yet the rhythm of the periods might be much more regular.

My problem emphasizes the change in variability during the steadiness testing period, rather than the change in depth and rate from normal respiration. To detect this important index we may employ the mean deviation of depth and the mean deviation of rate of breathing as devised and described by Caster.[1]

1. Caster, J. of Gen. Psychol., 1930, 4, No. 1-4, P.142.

Apparatus

The apparatus was set up on a small laboratory table of convenient height before which the subject was seated. In order to record the changes in both thoracic and abdominal respiration, two Sumner pneumographs were secured to the subject. The tube connections from these instruments led to a glass T union from which the air disturbances were conducted by a single tube to the recording stylus writing on the smoked drum of a standard vertical kymograph.

When the subject was seated, he faced a 9 hole Stoelting steadiness tester placed directly before his right hand and at the level of his elbow at the edge of the table. The insulated stylus was wired in series with an electric Vedder counter and an electro-magnetic marker. The current was supplied from four dry celled batteries. A contact of the stylus with the metal sides of the hole closed the circuit, and the electric market recorded an error on the kymograph drum. Time was recorded by a Jacquet chronograph in one second intervals. The kymograph drum was concealed from the subject by means of a large white cardboard screen. None of the subjects were aware of the general purpose of the experiment.

A diagram of the arrangement of the apparatus is included as well as a sample record describing the variations and methods of computing indices.

Procedure

The subjects for this experiment were student volunteers from the classes in Psychology la and Psychology lb. There were in all 26 subjects, 11 women and 15 men, sophomores or juniors in the University of Arizona, and ranged in age from approximately 18 to 23 years of age. There was no indication that they were other than normal physically. This experimental squad were carefully selected from 50 volunteers, from whom 26 were to be chosen for the crucial experiment. For several weeks practice records of respiration were taken from these subjects. The purpose of these tracings was to ascertain the best subjects, accustom them to the general procedure and the apparatus, and to improve the technique of the experimenter. The steadiness test was not used in these preliminary trials. Normal breathing was recorded; subjects were asked to work arithmetic problems; to read; to take deep breaths; and to breath rapidly. All characteristic respiratory changes were noted. After testing the volunteers twice, those whose respiration showed tracings of sufficient amplitude were chosen as members of the experimental squad.

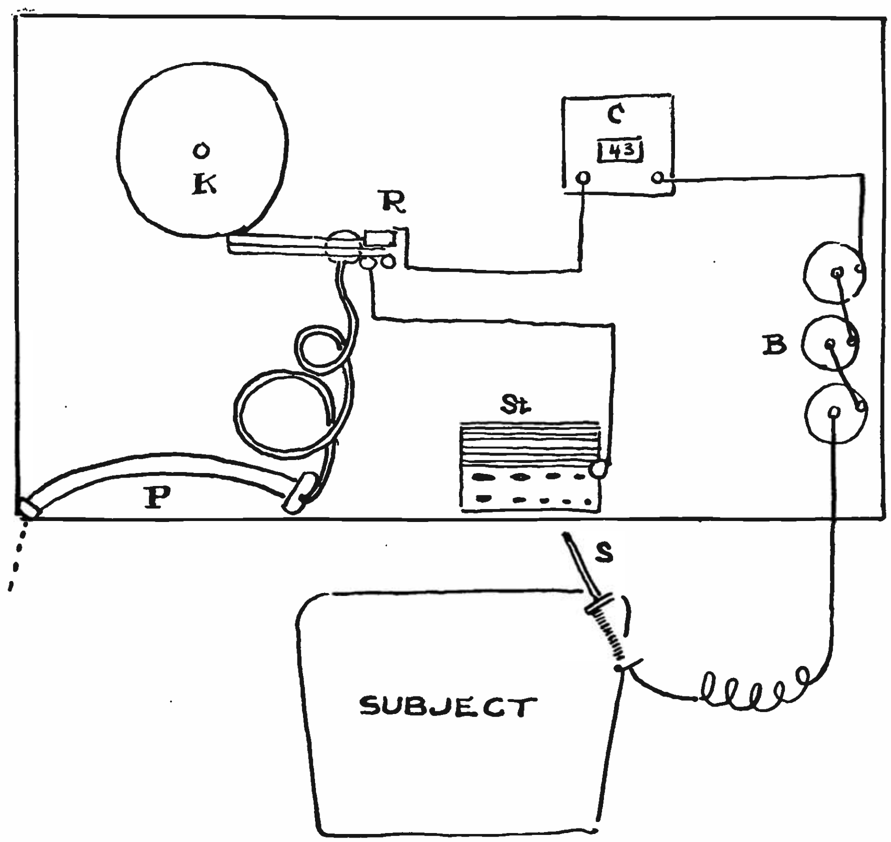
Each subject was assigned a definite time two days a week to report at the laboratory, thereby keeping controlled as well as possible such previous activities as classes, meals, etc. Each subject rested at least ten minutes before being tested to discount any rapid breathing as a result of climbing stairs, running, or rapid walking.

The pneumographs were then placed around the subject, he was seated at the table, and was given the following instructions: "When I give the signal, you are to place the stylus in this smallest hole and leave it there until I say, 'Stop'. It will not shock you. You are to try to keep the stylus from touching the sides of the hole. I will give you a warning signal, 'Ready', and then I will say, 'Go'. Don't rest your hand on the table, but keep the stylus in the middle of the hole with your hand and arm free. Until I give you the warning signal, sit back and relax. Try not to think about your breathing. Think of the color black."

The kymograph drum made one complete revolution in two and three quarters minutes, which were divided into one minute of normal tracings, 30 seconds of steadiness testing, during which the subject attempted to keep the stylus in the hole without touching the sides; then 45 seconds of normal breathing, and 30 seconds of steadiness testing. The subject was given a 5 second warning period before each of the two steadiness tests.

There were no instructions for the records taken next. The subject was told to repeat what he did last time. Thus I secured approximately two such tracings from each subject, the best one of which was selected for measurement and computation.

Diagram of Apparatus



B.- Batteries
C - Counter
K - Kymograph
P - Pneumograph
R - Recorder
St- Steadiness Tester
S - Stylus

The next step of the experiment was concerned with providing a strong motivation for steadiness. In these records one minute of normal breathing was recorded, then 30 seconds of steadiness testing, then 30 seconds of normal breathing. At this point the drum was stopped, and the subject was given the following instructions: "I have been reading up on steadiness testing, and I found an experiment conducted by a Doctor at the University of Michigan. He found a very high correlation between native intelligence and ability to hold the needle steady. I want to see if I can substantiate his findings in my experiment. So try just as hard as you possibly can to keep the needle away from the sides of the hole. I think the record so far is 10 errors, and I want to cut it to below 5 if I can. Put every bit of your effort on keeping it away from the sides. I will take a normal tracing now, so sit back till I give the warning signal."

Two of the subjects reported afterwards that they had caught on to the ruse, but wanted to cooperate, and had bent every effort toward being as steady as possible.

Thus it will be seen that from each of the 26 subjects I secured two smoked records for computations, the first with a seauence of one minute of undisturbed breathing, 30 seconds of steadiness testing, 45 seconds of undisturbed breathing, and 30 seconds of steadiness testing; and the second record with a sequence of one minute of normal breathing, 30 seconds of steadiness testing, 45 seconds of undisturbed breathing, and 30 seconds of steadiness testing under strong suggestion. After discarding three records because of laughing, giggling, or talking, which produced artifacts, 23 records were left for computation.

Results

Reference at first should be made to Figure I which is an actual kymograph record for Subject XVIII. Reading from top to bottom A is the pneumogram, B, the record of contacts of the stylus against the metal of the steadiness tester (errors), and D, the time in seconds. Numbers reading horizontally indicate as follows: 1 a portion of the record of normal respiration, 2 the warning signal to insert the stylus in the hole. It will be noted that a deep inspiration was taken, followed by expiration almost immediately. Then occurs a shorter quick inspiration at 2b, followed by a slow expiration. The slight irregularities on the crests of the waves constitute a record of heart pulsations, communicated through the chest to the pneumograph. Note the deep compensatory inspiration following the test period which terminates at 3. This is the characteristic sigh of relief due to a condition of dyspnea built up through shallow breathing during the test. Normal respiration now follows for three phases. At 4 the drum was stopped for a moment in preparation for the strong suggestions given at 5. Note the smaller number of contacts made during this period from 5 to 6. This section is also followed by a deep inspiration, not reproduced in the tracing. The errors appear to occur (line B) during

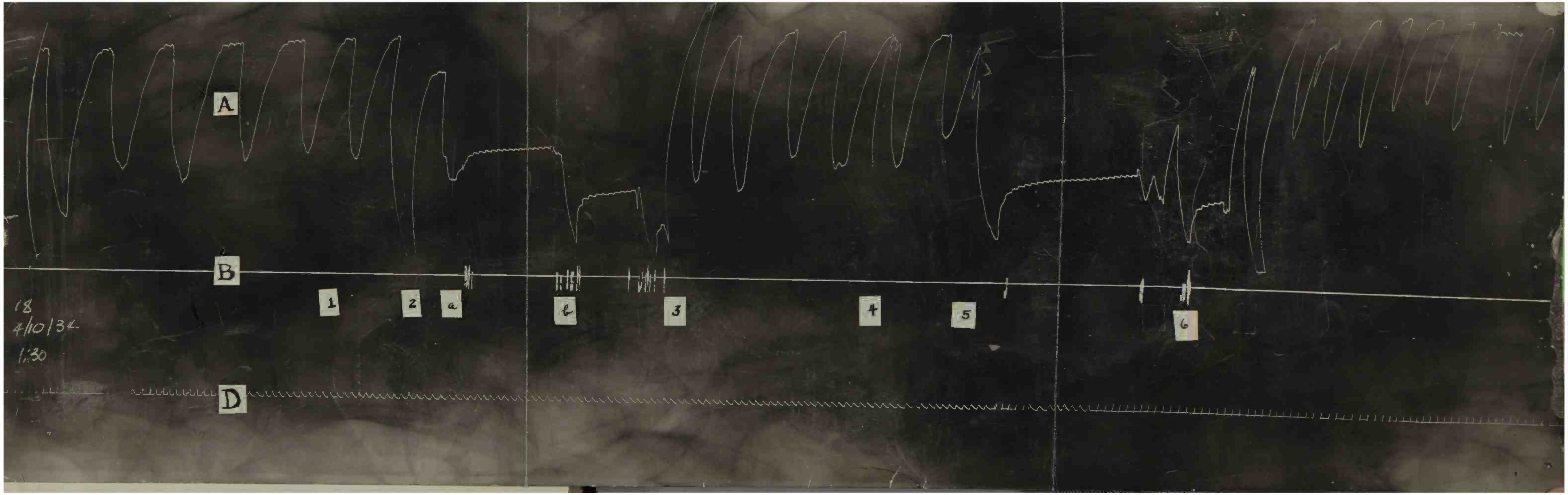


Figure I.

Tables Ia and Ib show the increase in percentage of the variability of the amplitude and rate respectively, during steadiness testing over the variability during normal, restful respiration. The data is grouped in columns for each of the 23 subjects as follows: 1, the average increase of variability of the first steadiness test over the undisturbed breathing which immediately preceded. 2, the average increase in variability during the second steadiness test over the undisturbed period immediately preceding. 3, the increased variability of the third test. 4, the increased variability in the fourth test, which was preceded by strong suggestion. The numbers in parenthese () indicate a decrease in variability during the stimulus period. A blank space indicates the presence of an artifact on the record which precluded the possibility of measuring accurately.

Table Ia

Percentage of increase or
decrease in variability
of amplitude

No. of subject	1.	2.	3.	4.
I.		620	65	77
II.	50	(8)	92	45
III.	409	0	850	0
IV.	33	192	557	1,007
VI.	(25)	220	104	211
VII.	147	71	98	98
VIII.	30	108	116	92
IX.	76	96	529	51
X.	60	735	273	109
XI.	(3)	28	(27)	(60)
XII.	144	(25)	950	47
XIII.	(34)		.1	151
XIV.	(57)	(13)	(6)	18
XV.	(38)	195	(30)	365
XVI.	168		16	91
XVIII.	0	307	1,080	1,045
XX.	209	(12)	(37)	415
XXI.	(89)	(8)	150	183
XXII.	35	78	25	63
XXIII.	(24)	(38)	9	9
XXIV.	154	12	173	181
XXV.	846	333	210	182
XXVI.	515	182	748	221
Av. Inc.	201	198	318	221
Av. Dec.	(38)	(20)	(25)	(60)

Table Ib.

Percentage of increase or decrease in variability of rate

No. of subject	1.	2.	3.	4.
I.		266	(13)	71
II.	(15)	(56)	11	500
III.	15,225	0	868	0
IV.	194	968	942	900
VI.	8	60	181	124
VII.	2,485	22	294	242
VIII.	143	50	22	(16)
IX.	285	95	820	190
X.	66	356	920	587
XI.	(77)	(14)	52	(17)
XII.	56	411	306	733
XIII.	92		276	1,450
XIV.	259	183	2	38
XV.	93	(20)	316	700
XVI.	(15)		20	70
XVIII.	288	1,275	434	272
XX.	0	(12)	19	66
XXI.	10,837	773	740	2,092
XXII.	483	511	300	130
XXIII.	140	(72)	200	266
XXIV.	150	540	400	(50)
XXV.	1,516	1,250	185	151
XXVI.	135	35	3,540	558
Ave. Inc.	1,713	450	493	481
Ave. Dec.	(35)	(34)	(13)	(27)

the phase of inspiration, but due to the fact that the two styluses were not exactly in line, the contact marks are displaced slightly to the right. The errors are therefore seen to occur during the phase of expiration generally; a quick inspiration usually followed an error rather than preceded it.

As stated above the data examined in this study were taken from two representative records from each subject. The results of the experiment may be divided into two general classes, data derived from a comparison of respiration during steadiness testing, and respiration during a normal, restful state; and data derived from responses following suggestion as compared to normal, undisturbed respiration.

In the first group, the main consideration concerns the effect of steadiness on the variability in amplitude and rate. To secure these results I have computed the mean variability of the amplitude and the rate for a normal tracing preceding the test for steadiness, and for the steadiness testing itself. This involved the technique suggested by Caster.[1] Since two records from each subject were used, there are four groups of normal and stimulus tracings for each subject. From the mean variability, Tables Ia and Ib were compiled to show the average increase or decrease in variability of amplitude and of rate for each of the four periods. A summary of these

1. Caster, Op. Cit., P. 142.

variations is shown by Table II which gives the percent of subjects showing increased and decreased variability in rate or amplitude in the steadiness testing for each of the 4 groups. It will be seen that 39% of the subjects showed an increased variability in amplitude over the undisturbed preceding respiratory period, in all 4 periods, and 52% of the subjects showed an increased variability of rate in 4 tests. The total number of tests upon which my computations are based is 89, and of this number 71 showed an increased variability of respiration during the test in amplitude, and 77 in rate. The average of the decrease in variability due to steadiness testing is much less than the average of the increased variability; the average decrease ranges from 20% to 60% in amplitude, and 13% to 35% in rate in each of the 4 tests, whereas the average of the increased variability ranges from 201% to 318% in amplitude and 50% to 1713% in rate.

Aside from increased variability in general during the testing period, there seems to be no other central tendency. The average increase of variability for each pair of normal-stimulus tracings varies for each of the four groups, as will be seen by reference to Tables Ia and Ib. Also, there is great variation in the increase or decrease of amplitude and rate for each subject from one tracing to another. For example, the variability in amplitude for Subject XII is a

Table II.

	Percent of subjects showing increased variability				Percent of subjects showing decreased variability				
	4	3	2	1	4	3	2	1	0
Amplitude	39	26	26	8	0	13	17	13	56
Rate	52	21	21	4	0	4	4	30	60

Table II. represents the percentage of subjects showing increase and decrease respectively in the variability of the steadiness testing period over the normal period for 1, 2, 3, 4 periods of the experiment.

144% increase for the first group, 25% decrease for the second group, 950% increase for the third group, and a 47% increase for the fourth group.

In the case of Subject III, the breath was held during the entire steadiness testing period in two out of the four trials. The mean variability of the amplitude did not change during a steadiness test for one subject, and the variability of rate of respiration did not change during the test of another subject. Aside from these two exceptions, either a marked increase in the mean variability or a slight decrease in variability was demonstrated.

I was also interested in a possible relation between the number and occurence of errors, and the phase of respiration; there appears to be no significant relation with one exception to be described presently. There is great variability from one subject to another in the form of the respiration. Some of the subjects exhaled their breath very slowly throughout the entire time of steadiness testing, while others breathed rapidly and less deeply than during the normal period, and a varying number of errors are found with all general patterns of breathing. On records with comparatively few errors, they may be distributed in groups at the first, in the middle or at the end of the stimulus period. The same holds true in cases where a great many errors were recorded. However, there is one general tendency to be noted. The experimenter observed that when there was a long expiration, and a sharp inspiration, the inspiration usually took place immediately after an error was committed rather than before. The error seemd to release the tension for an instant, and the subject took a quick breath.

Several other modifications of respiration were noted on close examination. In all cases there was a change in the form of the breathing, in regularity, amplitude, rate, or in all three during the steadiness testing. This may be clearly noted on the sample record in Figure I. Inspirations followed expirations immediately without the normal inspiration expiration pause. In only one case was there a protracted inspiration. Obviously, therefore, most of the errors were committed on exhalations. There was usually greater disturbance in amplitude, rate and regularity during the first part of the steadiness testing than the last part. The subjects appeared to show adaptation to the test, and the breathing, although faster, is more regular toward the end in most cases.

The final problem concerns the effect of strong suggestion or motivation on the number of errors and the regularity of breathing.

Table III shows the average number of errors for the three steadiness tests, the number of errors in the motivated testing, and the decrease or increase in the number of errors due to suggestion. Thus it may be seen that in 19 out of the 23 cases, there was a decided reduction in errors, ranging

Table III.

I.	15	28	39	27	31	(4)
II.	21	36	16	24	8	16
III.	16	8	17	13	9	4
IV.	35	25	35	31	10	21
VI.	94	92	41	75	38	37
VII.	23	25	32	26	4	22
VIII.	26	21	41	29	37	(8)
IX.	13	12	20	15	4	11
X.	32	23	46	33	40	(7)
XI.	68	73	24	55	27	28
XII.	37	59	21	39	16	23
XIII.	16	12	16	12	15	(3)
XIV.	13	12	16	13	7	6
XV.	5	5	4	4	0	4
XVI.	14	12	26	15	8	7
XVIII.	20	21	16	19	4	15
XX.	32	26	8	22	0	22
XXI.	9	3	10	7	5	2
XXII.	27	12	11	26	7	19
XXIII.	25	25	20	23	12	11
XXIV.	30	48	18	32	16	16
XXV.	22	20	15	18	15	3
XXVI.	44	25	38	35	8	27
Average	27	27	23	25	13	15 (Decrease) 5 (Increase)

Table III. shows the approximate number of errors for each of the four stimuli, or steadiness testing periods. The average for the first three trials for each subject is given, the number of errors made during the steadiness testing period, and the average of the decrease and the average of the increase in errors due to suggestion. Any increase in errors due to suggestion is indicated by parentheses () in the sixth column.

from 2 to 37, with the average of the reduction in errors 15. In four cases there was an increase in errors, averaging, however, only five. The average number of errors is 25 per test, and the average number of errors during the motivated test is 13, showing approximately a 50% decrease in errors due to suggestion for the group. The element of practice enters in somewhat. In both the first and second tests there was an average of 27 errors, and in the third test there was an average of 23 errors. However, the reduction in errors between the second and third trials amounts to only 14%, whereas the reduction in errors between the third and fourth trials amounts to 43%. Therefore, the great reduction cannot be explained wholly in the terms of practice.

As to the variability of the respiration under strong suggestion during the steadiness testing, the breathing is on the whole more regular than during the other testing periods. In approximately only 1/3 of the cases was there more irregularity. There is no characteristic pattern for respiration under the strong motivation used in this investigation, the breathing usually following the same general outlines of the unsuggested testing a minute before. There is a much greater variation in the patter of breathing from day to day than from the tests without suggestion to the one preceded by strong suggestion.

Conclusions

1. There is typically a decided increase in variability in both amplitude and rate of breathing during steadiness testing, with a few cases of decreased variability, and two cases where the variability did not change.
2. There is no apparent relationship between form and regularity of breathing and the number and place of occurence of errors.
3. There is a decided reduction of errors due to strong suggestion in steadiness testing. This amounts to a little less than 50%.
4. Aside from being slightly more regular, the general pattern of breathing does not change as a result of strong suggestion.

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