THE INFLUENCE OF THE EMOTIONS ON RESPIRATION

by

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Columbia University

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The experimental investigation here reported concerned itself with the respiratory changes which accompany the six primary emotions, pleasure, pain, anger, disgust, wonder, fear, as well as laughter and hatred The respiratory changes studied are (1) duration of inspiration as compared with that of expiration, (2) changes in the depth or amplitude,(3) and changes in the amount of work accomplished per unit of time.

INTRODUCTION

This work grew out of a series of experiments begun in September 1911 and continued until January 1915 with a view of recording the influence of thoughts and feelings on the facial organs, known as "the muscles of expression." Over one thousand photographs of one individual,"A.F., were taken for this purpose and studied. Samples of these were published in a previous article[1]. Although the camera recorded a great many interesting and valuable facts, many of which were interpreted with considerable success by the 100 judges, thus verifying the mental states revived by A.F. and recorded by the camera, we felt a need of supplementing this knowledge by recording other expressive movements. In order to get good results, we made our task as simple as possible, and concentrated all our efforts in recording and interpreting the respiratory movements only. For this purpose, and as a preliminary study,

1. Psy. Review, Jan. 1914.

we had A.F. revive the various thoughts and feelings while the breathing movements were recorded.

The stimuli were the same as those used in posing before the camera: reciting poetry and prose; multiplying and other mental activities; reviving bodily movements of the emotions; sense stimuli, taste(sour, sweet, bitter), smell,sight, hearing(noise and harmony); feelings of strain, relaxation, fatigue, as well as the various sensations of pain (head, back, crushed fingers, toes etc).

We also studied the respiratory changes which accompany the various movements of the head, arms, upper portions of the body. In fact every conceivable movement was studied and recorded-chewing, swallowing sneezing, coughing, yawning, sighing, crying, speaking, singing and even dancing.

Many of the breathing records were genuine and spontaneous. For instance, while working one may naturally yawn or sigh from fatigue, swallow saliva, sneeze, cough, and make other movements such as'stop to think', 'stop to look', which leave their stamp on the revolving drum of the smoked kymograph. The records of the spontaneous and genuine movements do not differ from the records of the assumed or revived movements. This fact is of great importance, for it seems to prove tha the revived feelings express themselves as clearly in the respiratory muscles as they do in the facial muscles. This fact is also of great importance for us, as our experiment greatly depends upon the revived or imaginary stimuli. The reviving of habits of feelings and emotions need be no stranger than reviving the habits of walking, talking, writing, adding, multiplying. It is to be remembered that the newborn infant's experiences are first those of feelings of comfort and discomfort, of crying, sneezing, coughing, smiling, etc. In fact, almost all

the primary emotions are experienced long before he attempts to walk.

After having obtained over 100 records of A.F., we experimented with four other subjects, graduate students in psychology(two men and two women), also as a preliminary study, in order to involve a working method for our experiment. For a better understanding of the breathing curves, we recorded simultaneously the respiratory and facial movements (in the case of A.F. only).

From the results obtained, we concluded: first, that the respiratory muscles speak as clear a language as do the muscles of the larynx(voice), or the muscles of expression"(facial organs), but that the three supplement each other, and each must be interpreted. For example, in laughing, crying, yawning, wonder and disgust, the accompanying facial expressions are characteristic; the respiratory movements are modified, and record differently in each case; the vocal cords are thrown into characteristic vibrations. Second,,that the feelings and emotions are principally reflected in the "muscles of expression" and that of respiration.Third, that the emotions are intense feelings, and may be accounted for by the summation of stimuli.

The above suggestions and conclusions are not new. The physiological and psychological investigations on our subject need not be discussed here. However, we may draw attention to the following important facts: Charles Bell, the discoverer of Bell's law, Bell's Palsy(Facial paralysis, points out the fact that the act of respiration is not limited to the trunk, but also to the nose, mouth, the windpipe, the throat, the lips, so that the air may be admitted through them in respiration with a freedom corresponding with the increased action of the chest. He proves that the organ of breathing in its association with the heart, is the instrument of expression, and is the part of the frame by the

by the action of which the emotions are developed and made visible to us.[1] Sudden changes of color in the countenance denote disturbances in the heart's action; labored, irregular breathing of the chest, extending to the neck and face, mark corresponding interruptions to the action of the respiratory organ; and both give rise to the variety of expression, which man interprets as a natural language. Bell not only shows the natural association between the muscles of the face and that of respiration, but he also gives experimental and clinical evidence to prove that in facial paralysis, the muscles of the face are powerless, and the countenance acquires a characteristic look from the absence of all expression.

Darwin[2] points out that one of the most important facts brought out by Bell is that the muscles round the eyes are involuntarily contracted during violent respiratory effort, and that this fact aids to throw a great deal of light on many of the important expressions in man.

More recent investigations, including those of Mosso, Sherrington, Grile, and Cannon seem but to strengthen and uphold Bell's conclusions, which are also in accord with our own views. For our purpose, we may merely state that Mosso[3] gives evidence and concludes that "the emotions are principally reflected in the muscles of the face and that of respiration." Bell[4] as well as Mosso draw attention to the fact that the human countenance performs many functions: we find "the organs of mastication, of breathing, of natural voice and speech, and of expression. The face serves for the lowest animal enjoyment, and reflects the highest and most refined emotions."

1. "When a horse has run and pants and breathes hard, the nostrils are alternately dilated and contracted, while the chest rises and falls. So in man, excited by exercise or passion, the shoulders are raised at each inspiration, the muscles of the neck and throat are violently drawn, and the lips and nostrils move in time with the general action."(The Anatomy of Expression by Chas. Bell, p. 7, Second Edition. also Eigth Ed.)

2. Expression of the Emotions in Man and Animals, Chas. Darwin, p.2, 1878.

3. Fear, Angelo Mosso, p.184, 1896.

4. Op.cit., p.5 and 6.

Cannon[1] states that the differential features if emotions are not to be traced to the viscera, and that this view is also in accord with the experimental results of Sherrington.

Crile[2] states with Sherrington that "the environment drives the brain, the brain drives the various organs of the body." He adds that each separate motor action has its own brain pattern, which is adapted for but one type of motion, and that "the specific stimuli of the innumerable ceptersplay each upon its own brain pattern only. In addition each brain pattern can react to stimuli applied only within certain limits."

In regard to the psychological investigations, we must be brief. Both Stevens[3] and Shepard[4] publish experiments on organic changes and feeling and attention, and both review the writings on this subject. Stevens concludes that the psychophysical processes of sensation are different with the visual, auditory, and tactual. Shepard[5] studied Stevens's records and states that as far as any conclusion can be drawn from them, the differences are due to changes in breathing.

Our own observations seem to show that we may not only have visual, auditory, and tactual attention, but we may also have pleasant, fearful, angry etc. attention, and when the intensity of the feeling is increased, we experience the various emotions. We may say with Wundt[6] that intense feelings are emotions. "As a result of the summation and alternation of successive stimuli there is in emotion not only an intensification of the effect of the heart, blood-vessels, and respiration, but the external muscles are always affected in an unmistakable manner. Strong movements of the

1. Bodily changes in pain, hunger, fear, and rage, Cannon, p.280, 1915.
2. The Origin and Nature of the Emotions, G.W.Crile, p.90, 1915.
3. Study of Attention, N.C.Stevens, Am.Jour.of Psy., 1905.
4. Organic Changes and Feeling, J.F.Shepard, Am.Jour.of Psy., 1906.
5. The Changes of heart rate with attention, Billings and Shepard, Psy.Rev.1910
6. Outlines of Psy., 3rd Ed. 1907, W.Wundt.

mimetic muscles appears at first, then movements of the arms and of the whole body(pantomimetic movements). In case of stronger emotions there may be still more extensive disturbances..."

As each emotion has a characteristic expression, we may expect to find corresponding changes in the respiratory apparatus. This is the object of the following experiment.

APPARATUS AND METHOD

Records were taken of the respiratory movements by means of Ellis's pneumograph, a closed tube distended by a spiral spring and fastened around the chest of the subject. Inspiration changes the air pressure in the tube, and this change is transmitted to a Marey tambour which writes the respiratory movements on the smoked surface attached to a drum of Porter's Kymograph. Time in seconds was recorded by means of a Jacquet chronometer.

In order to simplify measurements, Benussi's[1] method of tracing each record on unit paper was employed. As millimeter paper was not available, the unit paper, having 1/20th of an inch to a unit was used. The beginning and ending of each inspiration and expiration was projected on that straight line which conformed to the horizontal position of the writing pen.

There were six subjects : A.F. who had training in posing for the various graded emotions with or without the camera, and five other women who had no such training. Among the latter were three actresses, one singer and one school teacher.

The subjects were seated in a comfortable position beside a table upon which stood the registering instruments. In order not to distract the attention of the subject, the instruments were hidden from view by a screen.

The questions asked and instructions given to the subjects were as follows:"have you ever found yourself smiling or laughing at some experience

1. Archiv. Gesamte Psy., Jan. 1914, p.341; Article "Die Atmungs symptome der Lüge" by V. Benussi.

which had previously made you smile or laugh ?" This question was answered affirmatively by all. "Now recall an experience which gave you pleasure and try gradually to increase this pleasure to your utmost capacity, then suddenly think of something funny and pleasurable, and begin to laugh." A similar question was asked in regard to the emotion of anger. The subject was then told to revive the emotion and gradually to increase the intensity and finally to say the words, "I hate you", at the same time to try as much as possible to feel this hatred. The same directions were given in the case of the emotions of pain, disgust, wonder and fear. The last four were merely increased in intensity without a change from pleasure to laughter, or from anger to hatred. Thus the revival of the six emotions, pleasure, pain, anger, wonder, fear, and disgust, which the writer considers the primary emotions, were employed.[1]

In order to make the situation as natural as possible, we had A.F., the trained subject,[2] assume the various emotions together with the other subjects. This helped to do away with some self-consciousness, which was very noticeable. This was more apparent in the school-teacher, who had no musical or dramatic training, than in the singer and the actresses, although all seemed self-conscious until A.F. worked with them. Attention must be drawn to the fact that the intensifying of the emotions in this manner is arbitrary, and not the natural mode of expressing them. Each situation will bring along with it a certain degree of emotion, but in order to study the various intensities of the different emotions pure and simple this seemed the most practicable way.

1. The seven primary emotions named by McDougall include fear, disgust, wonder, and anger. He adds the emotions of subjection, elation and the tender emotions and states that "from these seven primary emotions together with feelings of pleasure and pain (and perhaps also feelings of excitement and of depression) are compounded all, or almost all, the affective states that are popularly recognized as emotions." As our objectivised emotions (photographs) seem to show some overlapping in this classification, we therefore substituted pleasure and pain, which have characteristic expressive movements for elation, subjection, and the tender emotion. In fact, the parental instinct not only excites the tender emotions, but also all the emotions which we consider are the primary emotions.

2. See next page for foot note.

The first record was simply taken to orient the subject to his task. enlarged photographs of A.F. of the various degrees of pleasure culminating in laughter were shown to the five subjects. A normal curve was taken for some seconds, then one photograph was shown at a time. The subjects all smiled when shown the smiling expression and increased their smiling, corresponding to the intensity found in the photos. The breathing records also showed corresponding changes. Then the different emotions were revived.

It was to be expected that the effect upon the respiratory organs, produced by varying the intensity of the different emotions, would not turn out as perfectly as desired. Then again, the various emotions are inhibited more by some individuals than by others. One subject mentioned that she seldom is provoked to anger and seldom hates. The only person this subject ever hated was an uncle who defrauded her of an inheritance. Two other subjects were under the impression that laughing aloud in not proper, therefore they always suppressed it, or laughed inwardly. Thus taking into consideration the difficulties encountdred , and for the sake of uniformity, we have eliminated in our measurement all the curves with the exception of the five middle ones, which would give us only the medium degree of each emotion. In the case of wonder, where the curves are characteristic, one respiratory phase, which includes an inspiration and an expiration, was all that was necessary for measurement. The downward stroke corresponds to inspiration and the upward stroke to expiration.

The following figures show the character of respiration during normal breathing, and the medium degree of the emotions of pleasure, pain, anger, disgust, wonder, fear, laughter and hatred. The amount of respiratory work

2. It is well known that just as a frightened animal may communicate fear to another animal, so may one individual spread joy or fear to another. Thus our stimuli consisted not only the revived emotional experiences of the subject, but also the bodily expressions of the emotions in another individual.

accomplished per unit of time was found by dividing the amplitude, which is both force and distance, by the time taken for each respiratory phase. Thus the sum of the five middle amplitudes or inspirations was taken and divided by the time taken by five inspirations and five expirations. In the case of wonder only one amplitude was measured.

TABLE I.

1. Normal

		I/E	DEPTH	Work per sec. in units where one unit equal 1/20th of an inch.
Subject	A.F.	.77	12.7	5.18
"	F.M.	.81	14.24	4.73
"	M.M.	.83	14.20	4.09
"	D.L.E.	.79	11.70	4.09
"	L.S.	.75	15.-	5.76
"	I.M.	.91	16.60	4.20
Average		.805	13.89	4.67

2. During Disgust.

		I/E	DEPTH	Work per sec.
Subject	A. F.	.95	7.90	4.44
"	F.M.	1.24	8.70	4.21
"	M. M.	.88	17.-	5.70
"	D.L'E	1.07	21.90	5.01
"	L.S.	.75	24.20	9.75
"	I.M.	1.93	14.20	8.73
Average		1.08	15.31	5.98

3. During Wonder.

		I/E	DEPTH	Work per sec.
Subject	A. F.	3.50	17.-	7.66
"	F. M.	2.15	40.50	8.15
"	M. M.	3.-	34.-	8.85
"	D.L'E.	3.35	32.-	4.18
"	L.S.	1.84	15.-	9.68
"	I.M.	2.14	32.-	4.78
Average		2.49	38.58	6.39

4. DURING PAIN

		I/E	DEPTH	Work per sec.
Subject	A. F.	2.-	28.50	8.16
"	F.M.	1.70	22.40	3.71
"	M. M.	1.12	29.50	5.70
"	D.L'E.	1.71	37.70	6.98
"	L. B.	.78	27.80	14.68
"	I. M.	1.97	34.-	9.03
Average		1.546	29.85	8.028

5. During Pleasure.

		I/E	DEPTH	Work per sec.
Subject	A. F.	1.05	24.-	9.12
"	F. M.	1.33	30.10	9.85
"	M. M.	1.10	24.10	8.15
"	D.L'E.	1.28	31.20	7.58
"	L. B.	1.20	21.80	12.33
"	I. M.	.73	28.40	11.47
Average		1.11	27.28	9.485

6. During Anger.

		I/E	DEPTH	Work per sec.
Subject	A. F.	1.97	36.20	17.32
"	F. M.	1.36	25.50	10.92
"	M. M.	.84	32.30	16.69
"	D. L'E.	1.72	38.10	15.13
"	L. B.	.52	18.10	9.11
"	I. M.	2.57	40.50	10.13
Average		1.18	31.78	13.80

7. During Fear.

		I/E	DEPTH	Work per sec.
Subject	A. F.	3.31	22.30	15.88
"	F. M.	2.19	17.15	10.11
"	M. M.	2.55	41.90	23.20
"	D.L'E.	3.98	25.50	10.58
"	L. B.	1.59	62.-	13.70
"	I. M.	2.89	30.90	11.12
Average		2.88	33.19	14.57

8. During Laughter

		I/E	DEPTH	Work per sec.
Subject	A. F.	.32	31.-	11.58
"	F. M.	.39	22.80	7.31
"	M. M.	.34	21.65	11.66
"	D. L'E.	.22	30.60	9.-
"	L. P.	.36	20.-	4.47
"	I. M.	.27	30.60	6.47
Average		.30	28.55	8.415

9. During Hatred.

		I/E	DEPTH	Work per sec.
Subject	A. F.	.275	35.-	4.67
"	F.M.	.745	15.25	9.28
"	M. M.	.99	30.08	16.25
"	D. L'E.	.45	37.80	9.60
"	L.P.	.19	10.40	.88
"	I. M.	.14	12.-	4.095
Average		.515	28.42	7.482

Column I gives the results for the relation between inspiration and expiration. When I : E as 3 : 3, or 4 : 4, or 5 : 5, we get a ratio 1.- When the ratio is less than 1.- the time for inspiration is less than the time for expiratio . When the ratio is greater than 1.- then the time for inspiration is greater than that of expiration. The inspiratory pause was included as a part of inspiration, as may be seen in the characteristic curve of "wonder"; and the expiratory pause was considered as belonging to expiration, as shown in the breathing curves of laughter and hatred. Only the beginning of each inspiratio and expiration was marked off for measurement. That is the end of the first inspiration including what is considered a pause (if one exists) was ofcourse the beginning of the expiration ; and

the end of the expiration was the beginning of inspiration.

We may summarize in Table II and Table III, the average results and the mean variations of the respiratory changes, and the rate of work per second, during normal breathing and the medium degree of the six primary emotions. Laughter and hatred are tabulated separately (Table III).

T A B L E II.

Normal	I/E (in units)	DEPTH (in units)	Rate of work per sec (1 unit=)1/80th of an inch).
av.	.805	134.89	4.87
m.v.	.045	2.-	.55
DISGUST			
av.	1.08	18.91	5.99
m.v.	.33	5.71	1.45
WONDER			
av.	2.19	38.58	6.89
m. v.	.50	8.58	1.34
PAIN			
av.	1.548	39.65	8.038
m. v.	.398	4.14	2.57
PLEASURE			
av.	1.11	27.38	6.465
m. v.	.13	3.98	1.75
ANGER a.v.	1.18	31.79	13.810
m. v.	.57	8.85	3.08
FEAR			
a.v.	2.86	38.19	14.57
m.v.	.64	11.44	3.24

T A B L E III.

	I/E (in units)	DEPTH (in units)	Rate of work per sec. (as above) (in units)
LAUGHTER	.30	36.85	8.115
m.v.	.06	5.14	2.38
Hate			
av.	.515	38.42	7.462
m.v.	.24	11.49	4.35

The above record gives I : E :: 1 : 5(.805) during normal breathing. This

shows rather clear results when we consider that the mean variation is .045; and that the ratios obtained by various investigators vary from 2 : 3, 3 : 4, 4 : 5, or 6 : 7. (That is the time for inspiration is less than the time for expiration). The average depth during normal breathing is 13.89 (m.v. 2.-); and the rate of work per second is 4.67 units (m.v.-.55)- Fig. I gives A.F's and L. B's breathing curve during normal respiration. In the latter, the first five curves were measured; in the former, the last five curves

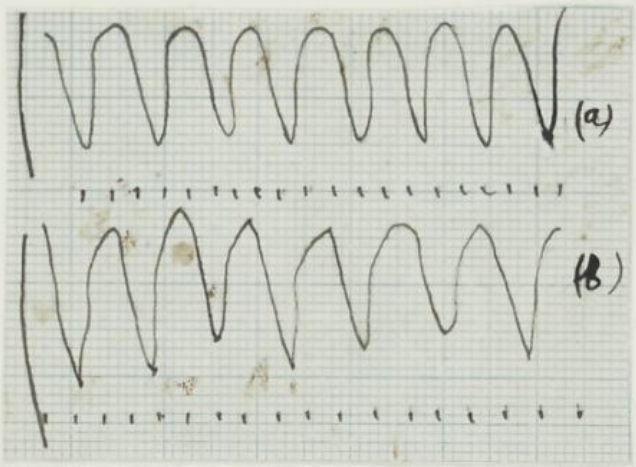


Fig. I.

(a) Subj. A.F.-I : E = .74 units; depth, 12.70; rate of work per sec.-5.18 un.
(b) " L.B. I : E = .75 " ; " 15.- " " " " " 5.76

In disgust the average ratio is 1.09 (m.v. -.33). Subjects A.F., M.M., and L.B. give less time for inspiration than expiration, while the other three

* We can in calculations convert 12.7 units (depth) into amount of air breathed in, which, in the case of A.F. is 218.44 c.c. These figures were obtained by breathing into a Standard Water Spirometer at various levels, not exceeding 40 c.i., while a pneumograph was strapped around the chest, and a record was obtained upon a smoked surface of a drum. These records were then measured by means of the unit paper. We thus calculated that one unit equals 1.04 c.i. or 17.9485 c.c. This is the average of 98 trials with levels ranging from 10 to 40 c.i. A.F's vital capacity was found to be 143 c.i. or 2938.84 c.c.

subjects give more time for inspiration than for expiration. The average depth is 15.31(m.v. 5.71). In order to explain this irregularity, we will introduce the breathing curves as shown in Fig. 2 It seems as though the subjects A.F. and F.M. inhibit their breathing to a much greater extent than the others. The nose is very largely a respiratory organ; and in disgust is often slightly contracted as partly to close the passage (Bell;Darwin). Then again the terms which express immediate petsonal attraction or repulsion are derived for the most part from the sense of smell and tase. To loathe is much the same as to be nauseated at some thing. Disgust is a strong term for personal repugnance, and even in its objective manifestation centres about the curl of the nostrils and of the mouth.[1] Then there are various ways of exhibiting disgust, as shown by Darwin.[2] If the guttural sound "ugh" is employed, as in the case of A.F. and F. ., then breathing is inhibited, and thus the rate of work. M.M. gives first a deep inspiration followed by a long irregular

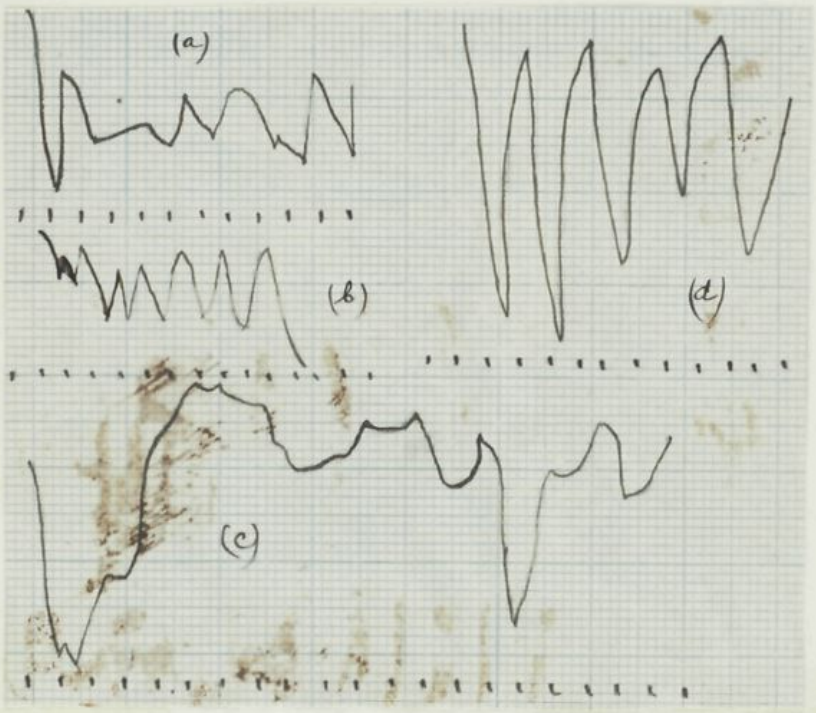


Fig. 2.

(a) Subj. A.F. : I : E= .95 units; depth, 7.9 : rate of work per sec., 3.44 units
(b) " F.M. " : " 1.34 " " " 8.7 " " " " " " 14.81 "
(c) " M.M. " : " .62 " " " 17.- " " " " " " 5.70 "
(d) " L.B. " : " .75 " " " 24.20 " " " " " " 8.75 "

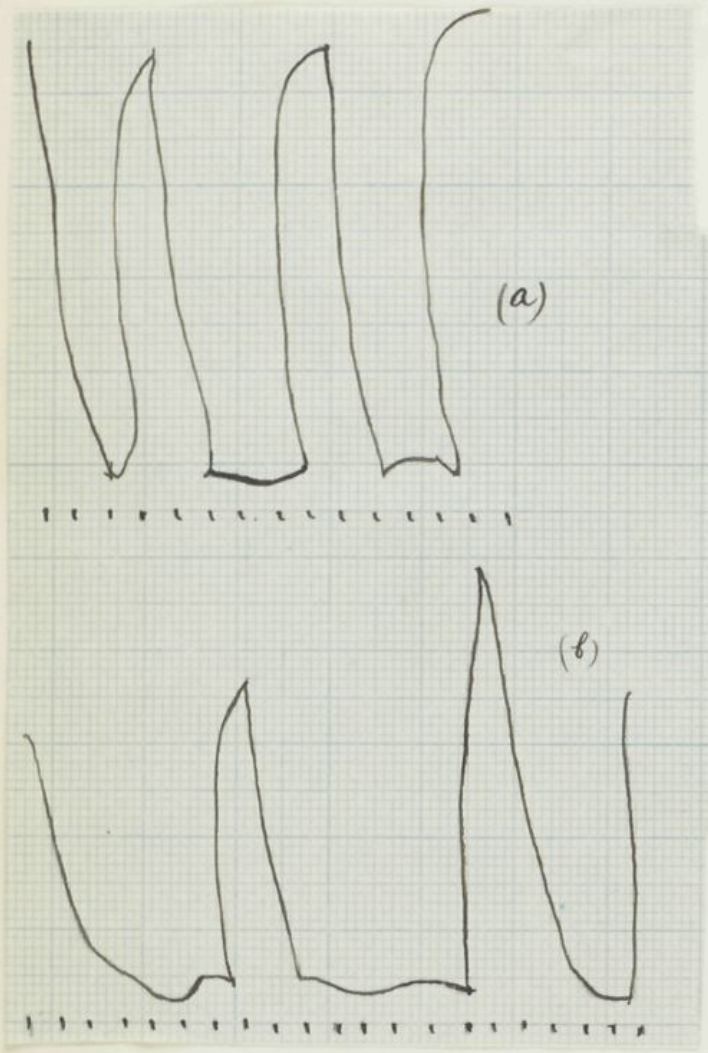
1. Psy. Dewey p. 867.
2. The Expression of the Emotions in Man and Animals, C. Darwin, p.258.

expiration and then inhibited respiration. A breathing curve similar to this, but a little more regular is given in Plate 2; and seems to be a typical curve for the "emotion"of disgust". That is, there is first a quick deep inspiration and then expiration followed by inhibited respiration.

Fig.3 gives the characteristic breathing curve of "wonder" with its decided inspiratory pause. The average ratio for the six subjects is 2.40 (inspiratory pause is included as belonging to inspiration), with a m.v. .80. This ratio does not differ greatly from the av. ratio of fear 2.60 (av. m. v. -.81) as shown in the records and in Fig. 4. In "fear", we find a gradual lengthening of the curve in some cases, while in others there is a slight inspiratory pause. L.B.'s fear breathing curve is somewhat similar to her "wonder" breathing curve as shown in Fig. 3, with the difference that "wonder" has the great inspiratory pause. Fear with a decided i spiratory pause is a complex emotion which may be either fear and shock, fear and wonder, or fear and surprise,.(The breathing curve of "surprise" is similar to that of wonder). However, the rate of work differs in the two emotions. There is much less respiratory work done during "wonder" than during "fear", but if the inspiratory pause is introduced into the "fear" breathing curve, the rate of work per sec. will be equivalent to that of wonder.

In "pain", the average ratio is 1.61%(m.v.-.398). Five subjects give more time for inspiration than expiration, while one subject gives less time. Subj. F. M. does 3.74 units of work per sec., while L.B. does 11.82 units per sec. The rate of work depends not only upon the amplitude, but also the respiratory pause. Fig 5. shows the inspiratory pause in F.M.'s pain breathing curve which lessens the rate of work per sec. I.M.'s curve shows five respirations in 21 sec., while L.B.'s curve shows five respirations in about 10 secs. Thus it seems that the rate of work also depends upon the rapidity of the breathing phases.

Breathing Curve During Wonder.



Breathing Curve During Fear

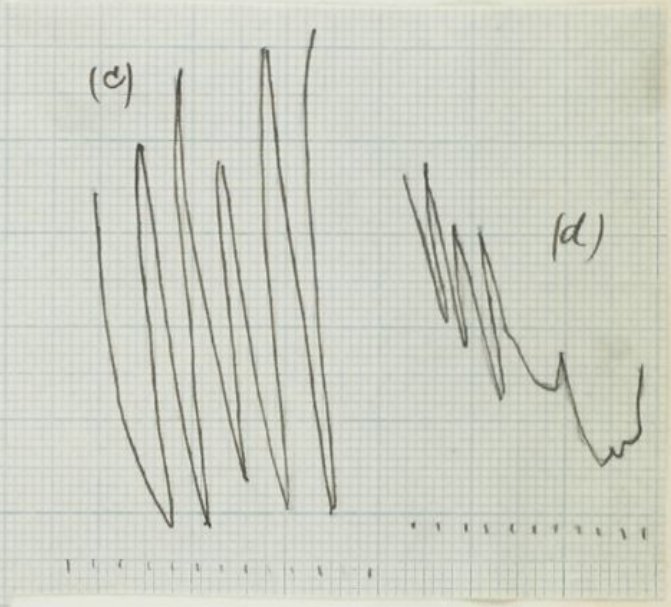


Fig. 4

Fig. 3

								per sec.
Fig. 3	(a)	Subj. L.B.	I : E = 1.84	units; depth	45	units; rate of work	9.68	un.
	(b)	" D.L'E.	I : E = 2.25	" "	38	" " " "	4.19	"
Fig. 4	(c)	" M. M.	I : E = 2.55	" "	41.80	" " "	23.20	"
	(d)	" F.M.	I : E = 2.19	" "	17.15	" " "	10.14	

In pleasure, the average ratio is 1.11 (m.v.-.15). As in pain, five subjects give more time to inspiration than to expiration, while subject I.M. gives more time to expiration. Fig 8, shows D.L'E.'s curve: five respirations in about 15 seconds (rate of work per sec. 7.58); and L.B.'s curve : five respirations in about 9 seconds (rate of work per sec. 12.33).

Breathing Curve During the emotion of "Pain".

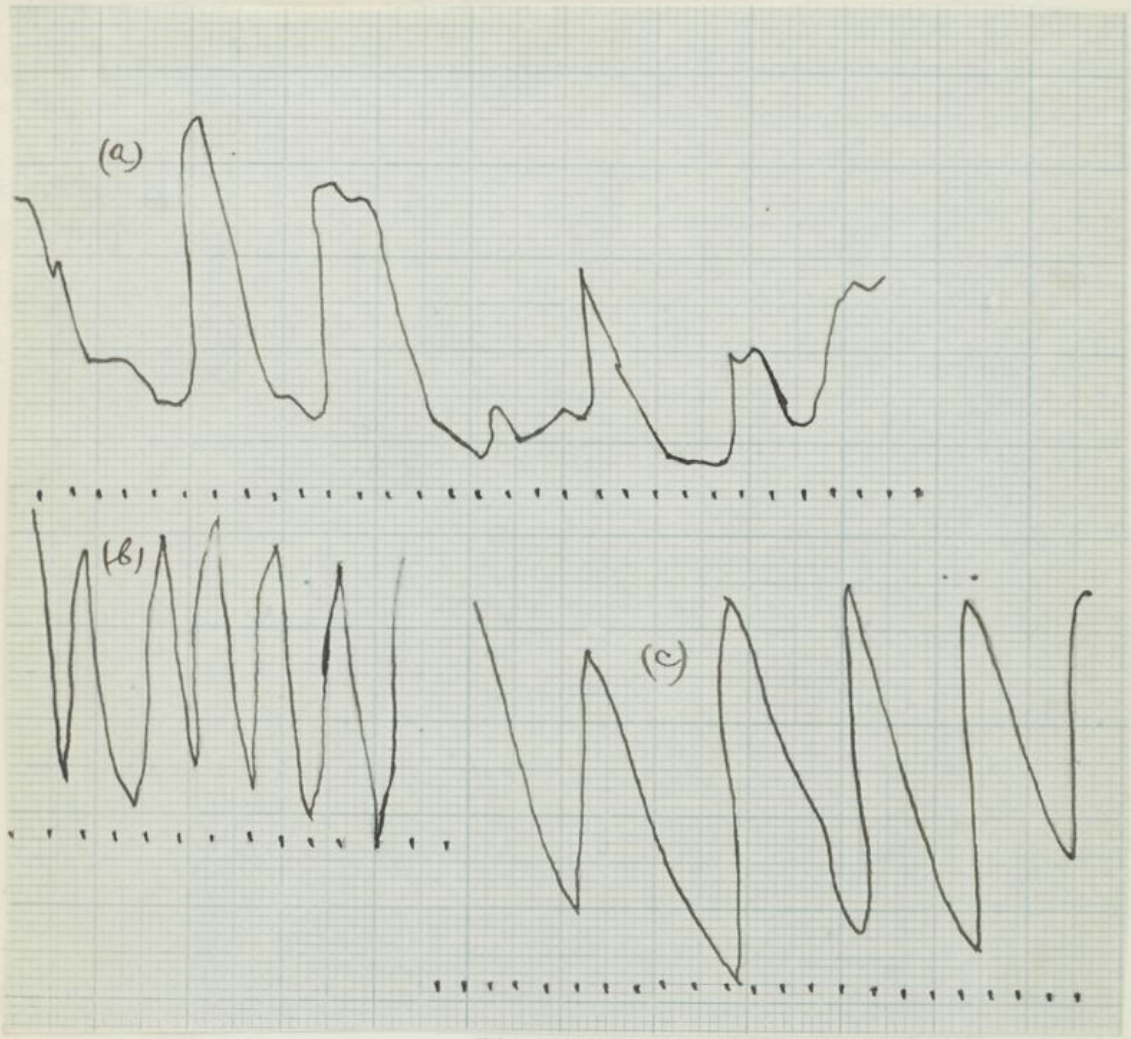


Fig 5.

(a) Subj. F.M. I : E = 1.7 ; depth 28.4 ;rate of work per sec. 34.74 units
(b) " L.S. I : E = .78 " 27.8 " " " " A 14.62 "
(c) " I.M. I : E = 1.97 " 34.- " " " " " 9.03 "

Breathing Curve During The Emotion Of Pleasure

Fig. 6.

(a) Subj. D.L. I : E = 1.26; depth 34.2 ; rate of work per sec. 7.55 units
(b) " L.S. I : E = 1.20 " 29.6 " " " " " 12.33 "

In "anger" four subjects give more time to inspiration, while two subjects give more time to expiration. Av. ratio = 1.18 (m.v. -.57) . The rate of work varies from 9.11 per sec. to 17.32 units per sec. This irregularity is caused by a slight inspiratory or expiratory pause due to swallowing or clenching the fists; to lack of uniformity in the amplitude; and to the breath rate, as shown in the records and in Fig. 7 .

Both Laughter and Hatred have characteristic breathing curves as shown in Fig. 8 and Fig. 9, as well as in Plates 4 and 5. In laughter I : E = .30 units. (m.v.-.06) ; and in Hatred I : E =.515 (m.v. =-24) -. It seems that the subjects were a little more successful in the expression of laughter than in the expression of Hatred. However, both show a decided respiratory pause.

Breathing Curve During The Emotion Of Anger

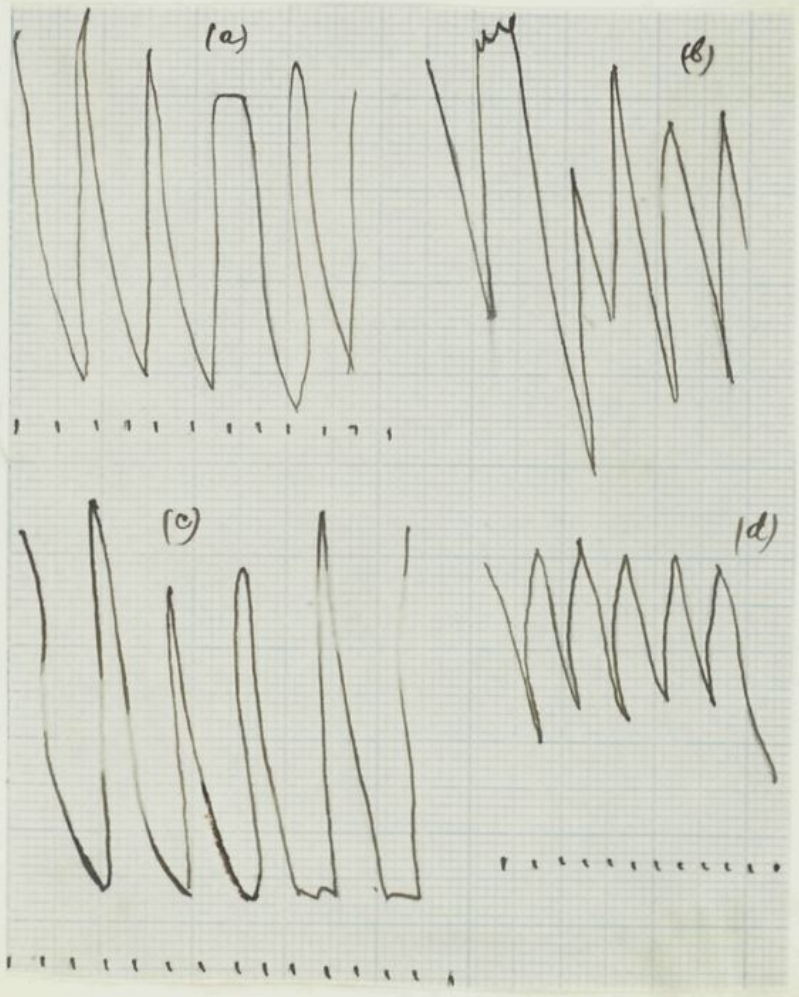


Fig. 7.

(a) Subj. A.F. I : E=1.87; Depth =36.20; Work per sec./17.32 units
(b) " W.M. I : E/ .84 " =32.30 " " " =10.82 "
(c) " D.L'E. I : E=1.72 " =38.10 " " " =15.13 "
(d) " L.B. I : E= .52 " =18.10 " " " = 9.41 "

Breathing During The Emotion Of Laughter.

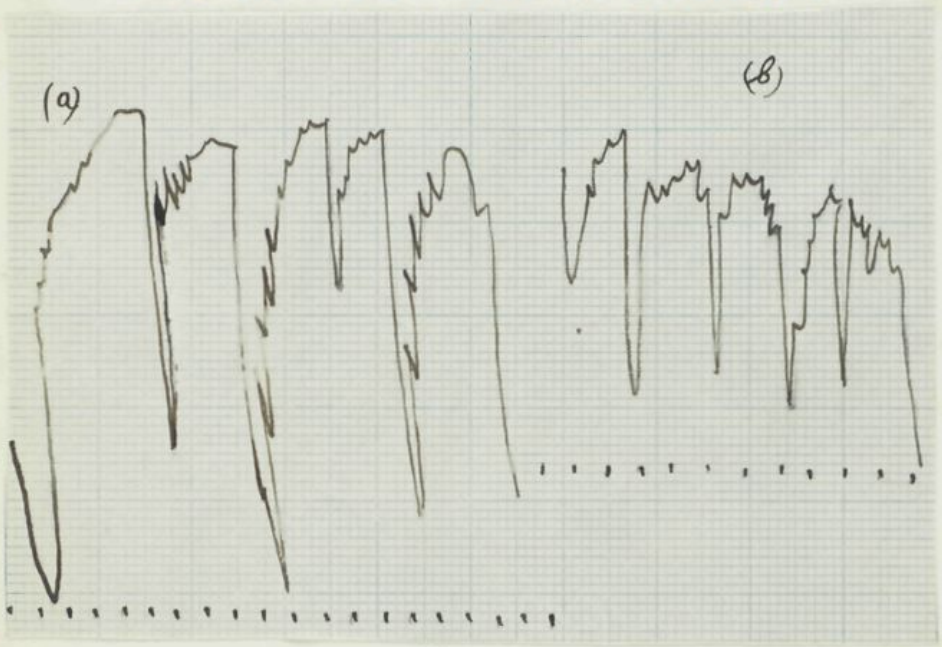


Fig. 8.

(a) Subj. D.L'E. I : E= .22; Depth = 30.60 units; rate of work per sec.= 9. units
(b) " W.M. I : E= .84 " = 21.65 " " " " " " =11.66 "

Breathing Curve During The Emotion Of Hate.

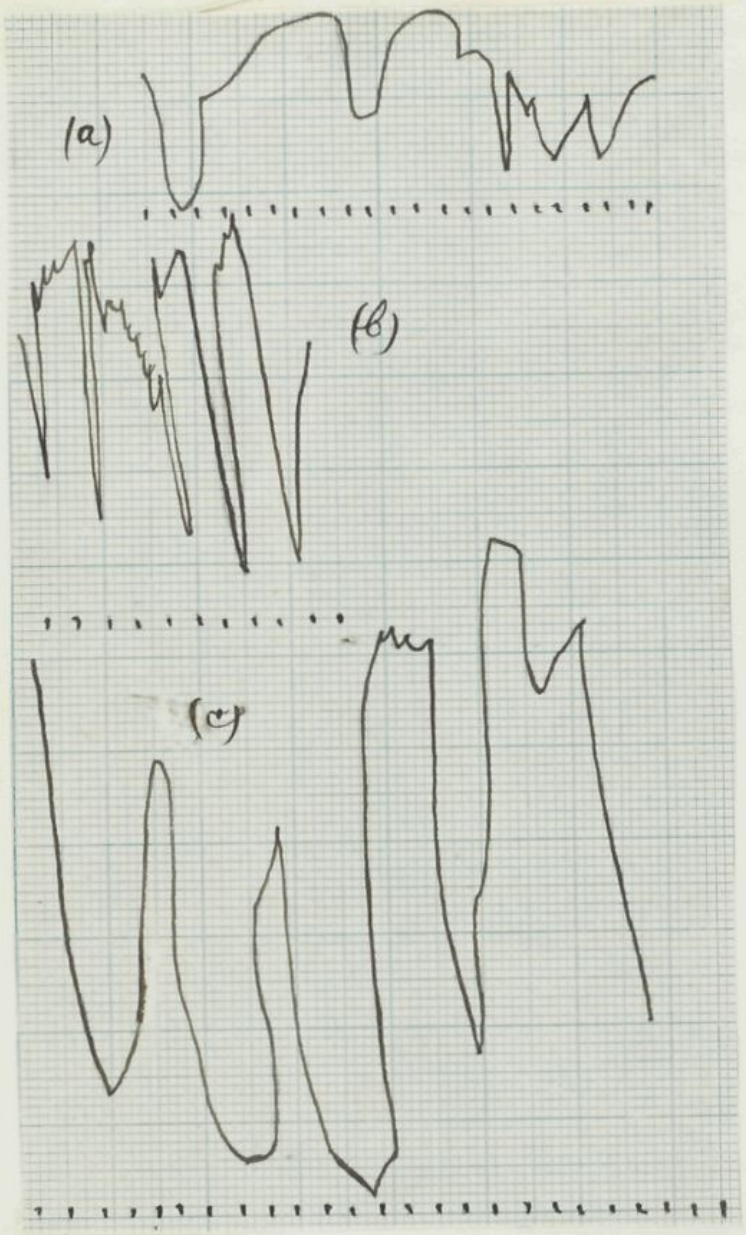


Fig. 9.

(a) Subj. L.B. I : E =.49 units; Depth=10.40; work per sec.= .88 units
(b) " A.A. I : E =.99 " " =30.08 " " " =18.25 "
(c) " D.L'E. I : E =.45 " " =37.80 " " " = 9.80 "

SUMMARY

When we compare the average rate of respiratory work per second for the six subjects with each individual record, we find great variability due,

perhaps, to the lack of uniform stimuli, to the lack of uniform intensity; as well as individual differences. Although irregularities are found, there seems to be a tendency to do much less work in wonder and disgust, than in anger and fear ; and less in pain than in pleasure. These facts do not contradict the data of ordinary observation. James has pointed out that "fear" has bodily expressions of an energetic kind, and stands, beside lust and anger, as one of the three most exciting emotions of which our nature is susceptible."* In wonder, we have an inspiratory pause which lessens the rate of work per second; while in hate we have the expiratory pause which also lessens the work per second. In disgust, the rate of work depends upon the depth of the first inspiration followed by an expiration, and the great inhibition of the following respiration. It is interesting to note that pleasure and pain appear side by side in order of work done per second. CHECK #1. As great irregularities were found in the depth of the curve, we have arbitrarily calculated the rate of work per second with an amplitude of one unit. Tables IV. and V. allow a comparison of results for the six subjects in order of respiratory work done per second with the original average, and when calculated with a depth of one unit.

TABLE IV.

FEAR	38.19	14.57	
ANGER	31.79	13.30	
PLEASURE	27.38	9.466	
(laughter)	(26.55)	(9.42	
PAIN	29.85	8.028	
(Hate)	(28.32)	(7.46	
WONDER	38.69	8.89	
DISGUST	15.31	5.93	
NORMAL	13.89	4.87	

TABLE V.

FEAR	1 unit	.3889	units.
ANGER	1 "	.4185	"
DISGUST	1 "	.3873	"
PLEASURE	1 "	.3475	"
NORMAL	1 "	.3368	"
(laughter)	1 "	.	(3167)
PAIN	1 "	.2797	
(Hate)	1 "		(2825)
WONDER	1 "	.1656	

Thus we find more work accomplished during "fear" and "anger" than during "wonder" and "disgust"; and more work done during pleasure than during pain. However, the "normal" and "disgust" rates have changed positions. The

* Wm. James Principles of Psy. Vol. II, p. 415.

"normal" holds the seventh rank in Table I, while it has the fifth position in Table II. Disgust which has the sixth position in Table I., occupies the third position in Table II. All that we can say is that when we calculate the rate of work with an amplitude of one unit, we ignore the form ofthe curve. Both the "normal" and"disgust"breathing curves possess characteristic forms, as may be seen in Figs. I and 1', as well as in Plate 2.

The "fear", "anger", "pleasure","pain", breathing curves have similar forms, and for that reason did not change their positions in order of work done per second, but were merely displaced by the "normal" and "disgust" breathing curves. This also holds true for "wonder", "hate", and "laughter" which are similar in respect to having either an inspiratory or expiratory pause which lessens the rate of work per second.

CHECK #2. In order to partly check up these results, we had A.P. pose before the camera, while the breathing movements were recorded on the revolving drum of Porter's Kymograph and the time recorded by Jacquet's chronometer.

The directions given were the same as those mentioned in the previous experiment: "look at a stated point, then look quickly into the camera and express the various degrees of (1) pleasure culminating in laughter, (2) anger culminating in hatred, and the various degrees of disgust, pain, wonder, and fear." As soon as A.P. heard the click of the camera, the second degree was assumed. The following photographs, breathing curves, and figures speak for themselves much better than any discussion might do.

Unfortunately all the scales are not as perfect as desired, due to fatigue and other disturbances. The error of execution may also be due "partly to an error of movement; and partly to an error in the intention," (Quoted from Elements of Exper. Phonetics, Edw.W.Scripturr,p.208). Nevertheless, we note that, in the medium degree, more work is done during fear and anger than during pleasure and pain or "wonder" and "disgust". However, although pleasure

and pain appear side by side in order of work done per second, more work is done during "pain" than during "pleasure" ; and more work is done during disgust than during wonder. These facts do not only contradict our former statement in regard to order of work done per second; but also contradict A.F.'s own record as may be seen in the following tables.

T A B L E VI.

Subject A.F. with photographs (medium degree).

Photo	40	Wonder	2.60	10.-	1.77
"	46	Disgust	.83	11.54	7.74
"	58	Pleasure	.93	22.16	10.08
"	52	Pain	1.27	23.10	12.06
"	64	Anger	1.19	22.25	13.68
"	70	Fear	2.16	23.88	14.97

T A B L E VII.

Subject A.F. without photographs (medium degree)

Disgust	.85	7.90	4.41
Wonder	3.50	47.-	7.66
Pain	2.-	28.50	8.16
Pleasure	1.06	24.-	9.42
Anger	1.87	38.30	17.32
Fear	3.31	32.30	15.68

It is self evident that a wonder breathing curve which gives I : E = 2.6 units and depth of 10 units will give different results when calculating the respiratory work done per sec., than the "wonder" breathing curve which gives I : E = 3.50 units and a depth of 47 units. The same may be said of the breathing curve of "Disgust". All this merely emphasizes the fact that we may expect to find as great a mean variation around the subject's own average, as around the average of a great number of observers. We may, therefore, for the present, consider our first conclusions as valid. And, as there is uncertainty and lack of uniformity is there need of further experiments, with

many trials for each subject.

It is interesting to note that in the small space, known as the face, we find assembled almost all the senses of the body, for the special senses are certainly present. Without words we may read the emotions of wonder, disgust, pleasure, pain, anger and fear. We also see the natural association between the muscles of respiration and that of the face (muscles of expression), for the mouth and nose are the respiratory organs (air passages) which carry the air to the closed cavity, known as the chest. We may safely say with Bell and Mosso that the emotions are principally reflected in the muscles of the face and that of respiration. The various emotions have characteristic expressions, and thus naturally we should expect corresponding changes in the respiratory apparatus.

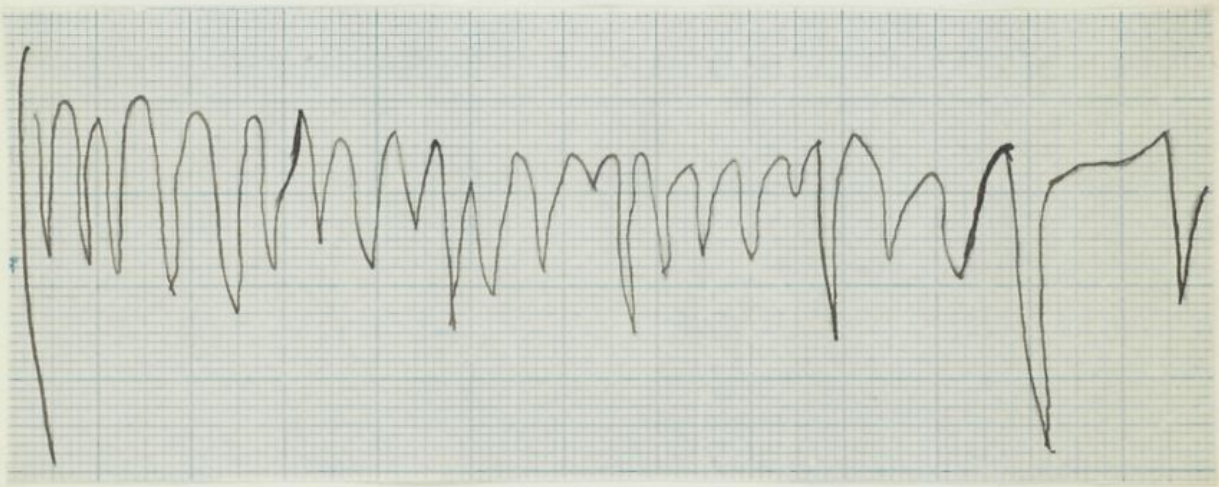
PLATE 1

37 38 39 40 41 42

Attention	(37)	1.25	19.50	9.71'
Wonder	(38)	3.55	20.-	8.30
"	(39)	20.33	25.-	4.39
"	(40)	2.80	10.-	1.77
"	(41)	6.60	21[-	3.24'
"	(42)	6.14	27.-	4.33

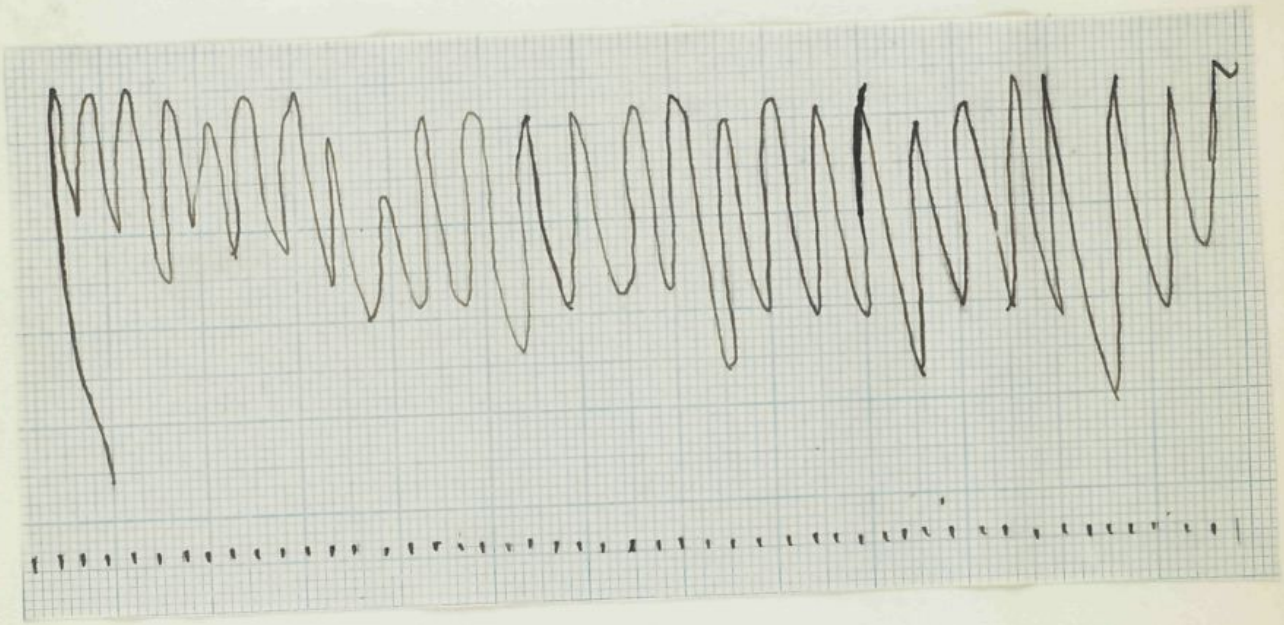
PLATE II.

43 44 45 46 47 48



		I/E	Depth	Rate of work per sec.
Attention	(43)	1.01	19.60	11.81
Disgust	(44)	.79	15.30	8.78
"	(45)	.87	13.-	8.03
"	(46)	.83	11.51	7.71
"	(47)	.41	15.58	6.03
"	(48)	.09	31.50	5.55

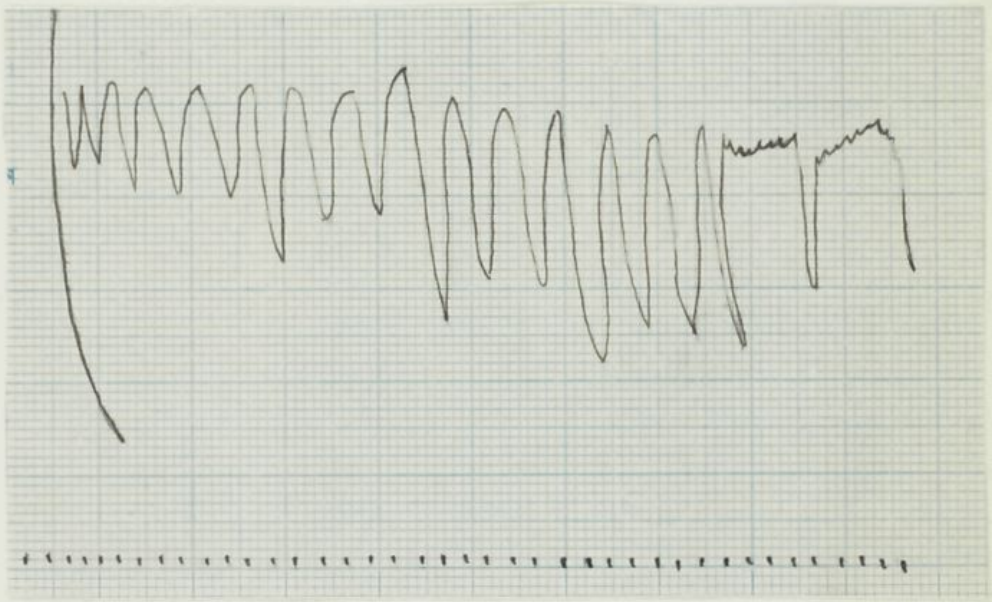
PLATE III.



		I/E	Depth	Rate of work per sec.
Attention	(49)	.98	15.87	9.19
Pain	(50)	.89	17.38	10.19
"	(51)	1.40	21.25	10.58
"	(52)	1.27	23.10	12.06
"	(53)	1.08	24.63	13.17
"	(54)	1.08	25.33	11.16

PLATE IV.

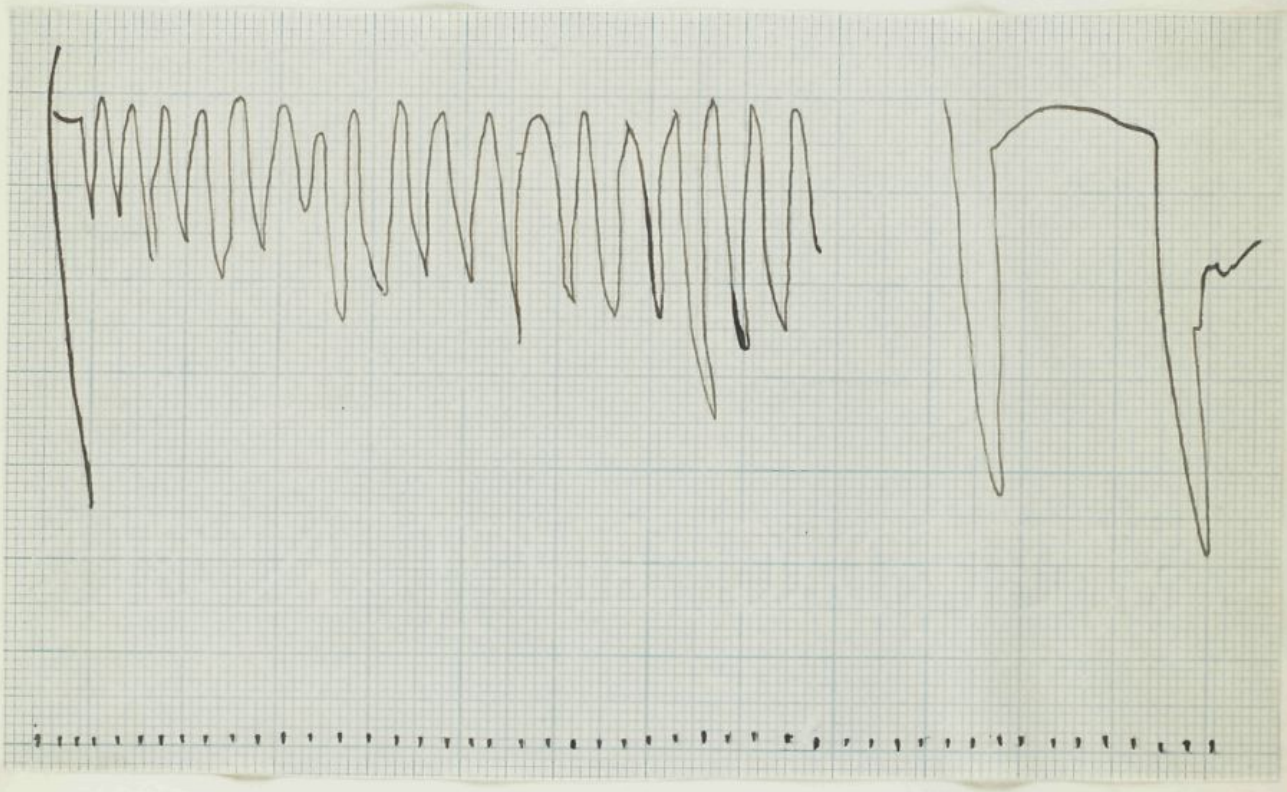
55 56 57 58 59 60



		I/E	DEPTH	Rate of Work Per Sec.
Attention	(55)	1.-	11.-	5.50
Pleasure	(56)	1.09	12.-	5.58
"	(57)	1.28	16.-	7.87
"	(58)	.83	22.18	10.09
"	(59)	.94	23.88	10.81
"	(60)	.18	19.75	1.98

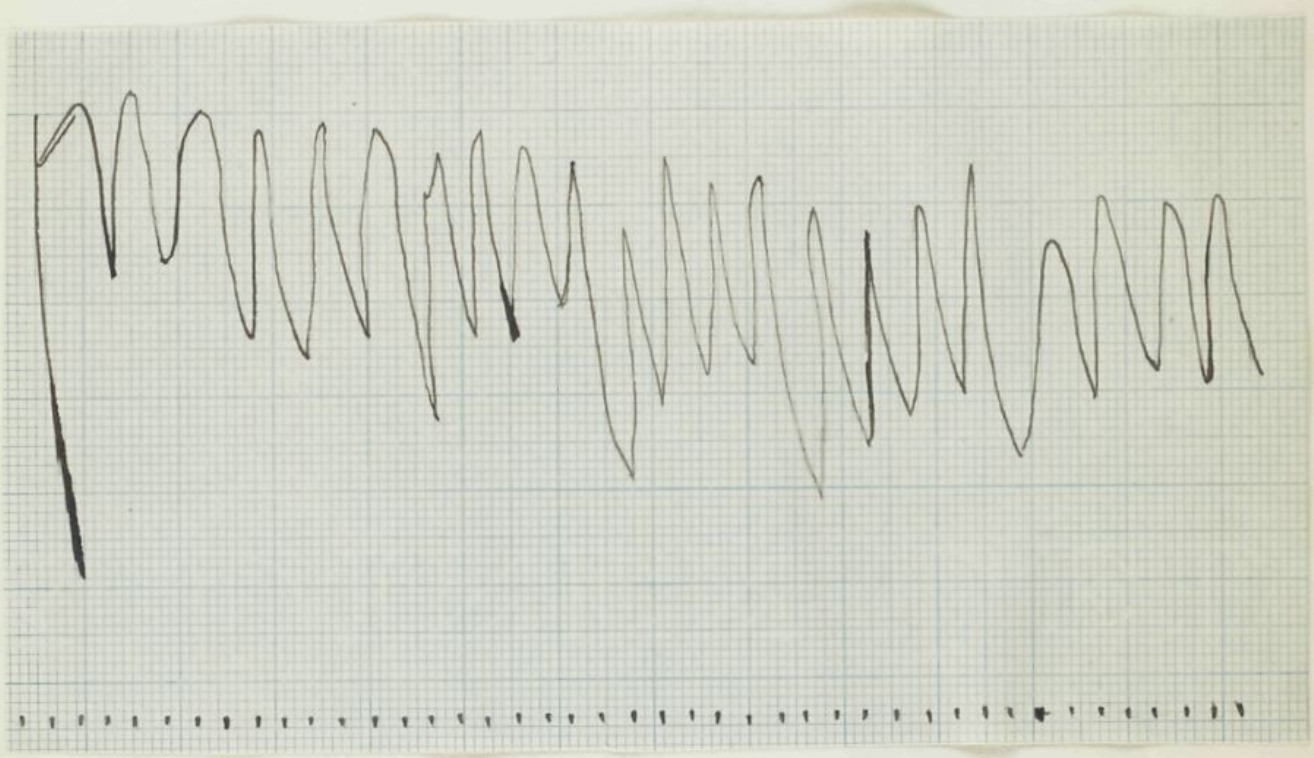
PLATE V.

61 62 63 64 65 66



		I/S	Depth	Rate of work per sec.
Attention	(61)	1.50	16.75	10.70
Anger	(62)	1.31	15.16	10.48
"	(63)	1.32	19.12	12.39
"	(64)	1.19	22.25	13.68
"	(65)	1.12	28.-	18.68
Hatred	(66)	.19	11.50	5.84

PLATE VII.



		I S	Depth	Rate of work per sec.
Attention	(67)	.73	17.75	8.62
Fear	(68)	1.43	23.-	11.87
"	(69)	2.12	28.63	14.45
"	(70)	2.16	28.88	14.97
"	(71)	2.26	24.25	13.47
"	(72)	1.89	21.375	10.18

M.A.

M.A.

Feleky

...Emotions on Respiration