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INVOLUNTARY MOTOR REACTION TO PLEASANT AND UN- PLEASANT STIMULI.

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Study of the emotions, in one way or another, has had a conspicuous place in the work carried on in the Harvard Psychological Laboratory. In this field of all others, perhaps, the investigator gains easiest access to the goal of physiological psychology—the determination, namely, of the quantitative and qualitative relations obtaining between those wonderful correlates, mind and body.

That elementary organism, the *amœba*, when jarred by its environment or more directly stimulated, contracts and tends to take the spherical form. On the other hand, all its movements of self-gratification are processes of expansion or extension. This observable double tendency seems to be the type, almost symbolically expressed, of a deep biologic law which science has shown to exist with almost infinite adaptation to circumstances and habit, in every organism. Experiment proves that, like other impulses of the lower animals, it exists persistently in man.

Professor Münsterberg has advanced the hypothesis that stimuli which cause action of the extensor muscles are as a rule agreeable, while stimuli which cause action of the flexor muscles are as a rule disagreeable. This tendency we should nat-

urally expect to find more fully and simply expressed in the case of the lower animals than in that of the higher. In early organisms such a correlation is necessary to ensure the survival of the organism and the possibility of evolution. For in the lower forms of life there should be such a strict correlation between the agreeable and the advantageous on the one hand, and between the disagreeable and the disadvantageous on the other, that the advantageous would be the agreeable and would be accompanied by expansion and movement towards the stimulating object, while any disadvantageous and consequently disagreeable stimulus would cause contraction and withdrawal from the stimulating object.

This correlation, however, would be more true in animals and savages than in civilized man. In our civilized state we have lost our primitive simplicity. We are still mal-adjusted to many civilized conditions, owing to our change of environment from the savage to the cultured state. By immediate inheritance and habit we have learned to control our motor reactions, to suppress the outward signs of our feelings. We often, perhaps mistakenly, think that even to ourselves as physical organisms, the disagreeable is advantageous and the agreeable is disadvantageous. We often enjoy pain and dislike pleasure. We have a thousand contradictory tendencies that run counter to any such simple rules of motor reactions as that above stated.

Yet in spite of these complications it is plausible that there exists the correlation claimed by Professor Münsterberg, showing itself strongly in the midst of conflicting tendencies. It was to test the validity of this hypothesis that the following research was conducted during the college year 1895-96.

It might be expected that a less educated class of subjects than those we have had would give more marked results, as far as reactions are concerned. Young children or savages would surely show motor reactions more strongly marked to disagreeable or agreeable stimulations. But even in our results, we have found a plain tendency in favor of the theory mentioned.

It must be mentioned that with many subjects we could get no perceptible reactions to the sensory stimuli. Some subjects seemed constitutionally averse to any motor reaction. The

stimulus would generally be pronounced either pleasant or unpleasant, and yet the subject would show no motor reaction whatever. This lack of reaction was very marked in some cases. In a few instances the subject pronounced the stimulus indifferent, yet often reacted to it one way or the other.

Some subjects were very sensitive and seemed to go all to pieces on any disagreeable stimulus, and would show most surprising and seemingly contradictory reactions. These points we will try to bring out fully in our statement of the results.

METHOD OF EXPERIMENT.

The emotional stimuli mostly employed were odors, but sounds and variously colored lights were also used, to a much less extent. It was greatly desired that the stimulus in each case should give an effect as purely painful or pleasurable as possible. Many subjects were employed and the stimuli were given often several times to each, on which accounts odors seemed the most fitting of possible agents. These furnish about the only means, indeed, of causing a constant pleasurable stimulation in the practice of the laboratory. Odors have the further advantages of being unlimited in number and in action independent of the subject's power of imagination. It was much more difficult to find for each subject a positively disagreeable odor than a positively pleasant one, students of chemistry being especially hard to suit with a sufficiently unpleasant smell. Constant care was needed and employed to suit the tastes of the various subjects in this regard, the objects being to employ types of pleasure and of pain.

The particular olfactory stimuli employed were kept in ounce vials on a stand made for them. It is hardly possible to make any classification of them as pleasant or unpleasant. Roughly, however, they may be arranged in the following order of agreeableness to the greater number of the subjects employed, the most pleasant first, but the middle ones varying greatly in this regard. Naturally the most emphatic members of the series were those most used. Oil of bergamot, cologne water, heliotrope, methyl acetate, oil of cloves, tincture of musk, ethyl iodide, spirits of turpentine, xylol, eugenol, oil of eucalyptus,

iodoform, cider vinegar, bisulphide of carbon, ethyl bomeol and camphor, sulphuric ether, toluidin, allyl alcohol, tincture of asafœtida, diamylamine, acetic acid, ammonium valerianate. A few subjects avowed no pain from any of these, and for these ammonia was employed in place of a real odor. It will be noticed that 'disgusts' are not included in our list, associations not being desired in these experiments, but only pure affective tones.

Panes of glass a foot square, colored red, blue, green and orange were used for subjects with color taste highly developed, the panes being held before their eyes. Similarly, for musical subjects, such sweet tones as tuning forks can give were applied as stimuli, with harsh noises for a contrary effect.

The hands and the head were chosen as the bodily parts most suitable for reaction, these being the most sensitive to motor stimuli and the most convenient. According to the theory in question, the hands should relax and the head drop back under agreeable stimulus, while under disagreeable stimulus the head should drop forward and the hands contract.

The mechanical plan employed for the direct registration of the flexion and extension of the head and hands was as follows: The subject was seated in a comfortable arm chair. A tightly-fitting pasteboard cap was placed on the head, from the center of which a strong thread extended over an easy-running pulley to the extremity of the lever of a Marey tambour. Because the antero-posterior movements of the head were sometimes considerable this lever arm was about twenty-five centimetres in length. By a careful centering of the pulley in the circle of head movements, record of the occasional lateral motions of the head was avoided, account of these not being desired. Pneumatic pressure transferred in the usual way the rise and fall of the receiving tambour's arm to the pen of another Marey tambour, writing on smoked paper on a revolving drum.

The apparatus adjusted to the left hand consisted of a bulb small enough to be fairly grasped in the closed fist. It was at first difficult to find a bulb without so much resistance to compression that the subject's constant attention was necessary to keep it in the state of partial compression needed to secure rec-

ord of the extensor movements of the fingers. But at last a bulb made of a soft sponge from which the center had been cut, enclosed in thin rubber dam, was hit upon, and this served as a most sensitive and, indeed, adaptable instrument; for sponges may be found or cut of any desired degree of resilience. The varying pressure of the hand was pneumatically carried to a receiving tambour and recorded on the smoked cylinder at the left of the tracing from the head.

To register the movements of the right hand in states of organic pleasure and displeasure a different form of instrument was employed. About the second and third fingers, as the most sensitive and most powerful, a comfortable ring of brass foil was fastened. This was attached directly to the lever of a tambour and as close to the fulcrum as possible, that all motion might be emphasized; and it was adjusted so that when the fingers were partially flexed the tambour rubber was plane. Comfort of the hand in this case was found important in order to avoid voluntary attention to it and its reactions. The flexor and extensor movements of the two fingers were as before transmitted to a pen tracing on the right of the record of the head.

To secure constant pressure at the start in the three sets of apparatus, the open ends of branches from the three conducting tubes were arranged side by side convenient to the operator, and fitted with clips so as to be simultaneously closed when all was ready and the kymograph in regular motion. The speed of the recording drum was such that one revolution was made in about five minutes. The cylinder was 14 cm. in diameter and 25 cm. long, suitable for two records such as these without change of paper. Straight normals for the better measurement of the curves were regularly run round the drum by stationary pens.

Record of the various conditions of each experiment was written with a stylus on each sheet, including name of subject, temperament, subjective experiences, stimulus, nature of effect whether pleasant or the contrary, date and direction of muscular movement indicated in each reaction. The subjects were mostly Seniors and Juniors of Harvard college and of Radcliffe college and graduate students working in the laboratory.

Their number was nineteen. Inquiries as to emotional likes and dislikes were regularly made and as to musical and 'artistic' education.

RESULTS.

1. *Under Pleasant Stimulation.*

Taking each movement or lack of movement, whether of head or of either hand, as a separate case, we have recorded 500 effects of sensory stimuli which were considered pleasant by the subjects. Of these, 118, or 23%, were cases of flexion of hands or forward movement of the head, 134, or 27%, were cases of no reaction whatever, and 248, or 49.6%, were cases of extension of hands or backward head movement. Considering the cases of actual reaction alone, there occurred 67% of movements of extension and 32% of flexion—a proportion of more than two to one. The tendency under pleasant stimulation is therefore strongly toward extension.

The two hands and the head did not necessarily act together in the same way. The left hand seems much more sensitive and more given to expressive motor reaction than the right, and as our subjects were mostly right handed, it would seem justifiable to infer from this that the right hand is more civilized and more under control and less naively expressive than the left. If the idea stated in the beginning is tenable, that civilized man is more likely to inhibit emotional expression than a savage, then we might expect the right hand to be the more inhibited and the less likely to react.

Counting the cases of pleasant stimuli where the left hand showed no reaction, we have for the left hand under stimuli pronounced agreeable results as follows: Flexion 21%, extension 60%, no reaction 19%. Out of 184 stimulations the left hand shows flexion 37 times, extension 112 times, no reaction 35 times. If we compare the left hand with the right, the percentage of 'no reactions' is seen to be much less for the left hand, while that of both flexions and extensions is greater. Under pleasant stimuli the right hand showed, flexion 20%, extension 40%, 'no reaction' 40%. That is, in a total of 130 cases, the right hand flexed 27 times, extended 52 times, showed 'no re-

action' 51 times. The left hand then was indifferent 19% when the right hand was indifferent 40% ; it extended 60% where the right hand extended only 40% ; and it flexed 21% where the right hand flexed 20%. Leaving out the cases of 'no reaction,' the right hand flexed 34% and extended 65% while the left hand flexed 25% and extended 75%.

As for the head under pleasant stimuli, it was found that it flexed, or came forward, 29%, showed no reaction 26%, extended or drew back 45%. That is, in a total of 186 pleasant stimuli, the head came forward 54 times, drew back 84 times, showed no movement 48 times. Comparing the flexions with the extensions alone, the head under pleasant stimuli was flexed 39% of the times, and extended 61%. The head was more indifferent than the total averaged results, but more expressive than the right hand.

It will be noticed, however, that the head shows more of a tendency to flexion under pleasant stimuli than either hand, viz., 29% flexion to 20% for right hand and 21% for left hand. This was one of the surprises of the experiments. In many cases under pleasant stimulus the head would move forward even where both hands relaxed. At first it was thought this was true only of smells, as the odors were necessarily presented suddenly and in front of the face, but the same thing was true of colors and sounds; the head often flexed when these stimuli were agreeable. This must have been an adaptive movement; for often, after this forward movement, the head would drop back during the continuance of the pleasant stimulus.

2. *Under Unpleasant Stimulation.*

If we now examine the head movements in response to unpleasant stimuli, similar differences of reaction will be seen. Here it flexed 42%, showed no reaction 19%, extended 38% ; or in a total of 168 stimulations it moved forward 72 times, showed no movement 32 times, dropped back 64 times. Taking flexion and extension alone, we find flexion 53% compared to extension 47%. Even more marked here is the tendency for the head to extend or draw back under an unpleasant stimulus than it was for it to come forward under a pleasant stimulus ;

while both hands often, and indeed generally, flexed. Yet for the head also flexion predominates, thus supporting the theory by a slight percentage. Comparing the hands as to their reaction to unpleasant stimuli, we find the right hand here also, markedly more inhibited or indifferent. The left hand shows flexion $66\frac{2}{3}\%$, no reaction 14.5%, extension 18%; or in 165 cases it flexed 110 times, showed no reaction 24 times, extended 31 times. Leaving out the cases of 'no reaction,' it showed 78% flexion, and 22% extension.

The right hand, however, flexed only 49.5% of the times, while it showed 'no reaction' 29%, and extended 21%. Comparing flexion and extension cases alone the right hand flexed 69% and extended 30%. The right hand, therefore, shows more of a tendency to indifference and extension under disagreeable stimuli than does the left hand. We find then, in the hands a marked preponderance of flexions under disagreeable stimuli, 78% of the movements in the left hand and 69% of the movements in the right hand being flexions.

Combining the cases of the reactions of head and hands under unpleasant stimuli we get 53% flexion, 20% 'no reaction,' 26% extension; or, in 450 cases we have flexion 240 times, 'no reaction' 90 times, extension 120 times. Leaving out cases of no reaction we have $66\frac{2}{3}\%$ flexions to $33\frac{1}{3}\%$ of extension—a proportion of 2 flexions to 1 extension.

3. Under Indifferent Stimulation.

In the cases where the stimuli were pronounced indifferent, that is, neither agreeable nor disagreeable, we find some interesting results. Even here the left hand reacted more than the right. The left hand under indifferent stimuli shows flexion 34%, no reaction 31%, extension 34%; or in 32 cases flexion 11 times, no reaction 10, extension 11 times. It is interesting that flexion and extension are here exactly equal.

The right hand under indifferent stimuli was more immobile. It shows flexion 30%, no reaction 50%, extension 20%; or in the 20 cases of indifferent stimulation the right hand flexed 6 times, showed no reaction 10 times, extended 4 times. Leaving out the cases of no reaction it flexed 60%, extended 40%.

The left hand showed only 31% of 'no reaction' under indifferent stimuli while the right hand showed 50%. The head under indifferent stimuli showed 30% flexion, no reaction 30%, extension, 40%; or flexion 43% to extension 57%, if we disregard cases of 'no reaction.'

The total results of the hands and the head for indifferent stimuli are 31.7% flexion, no reaction 35%, extension 32.9%; or disregarding the 'no reaction' cases, flexion 49% to extension 51%. Extension and flexion here are almost equal with a slight percentage in favor of extension, probably due to adaptive efforts. This is what we should expect under indifferent stimuli. We find also here more cases where there was no reaction than occurred when the stimulus was pronounced pleasant or unpleasant, viz., 35% here to 26% under pleasant and to 20% under unpleasant stimulation.

4. *Summary and Additional Observations.*

The foregoing results may be summed up in the following table. It includes only the actual reactions to stimuli, 764 in number. The cases where stimuli were applied without resulting reaction numbered 253.

	UNDER UNPLEASANT STIMULI.	UNDER PLEASANT STIMULI.	UNDER INDIFFERENT STIMULI.
Flexion	66.6	32.2	49
Extension	33.3	67.8	51
Proportion	2 to 1	1 to 2 +	Nearly equal.

These experiments afford, therefore, a striking confirmation of Professor Münsterberg's theory, that there is a strong tendency to expansion under agreeable, to contraction under disagreeable, stimuli. Other tendencies are present, however, some of which conflict with this one: such for example as the tendency to move toward an object which attracts attention; the tendency to move away from a disagreeable object; the tendency to make particular movements of adaptation to stimuli; etc. A further influence of great interest is revealed upon examination of the records of the separate individuals who, as subjects, took part in these experiments. If their reactions to stimuli which

they pronounced indifferent be examined, it will be seen that some show a temperamental tendency to make movements of flexion more often than of extension; others, the opposite; and others still to make both in nearly equal proportion. These temperamental tendencies show themselves clearly in their influence on reactions to agreeable and disagreeable stimuli. The 'flexion' temperament shows, through the greater predominance of flexions, a greater difference in the proportion of the two movements under pleasant stimuli and a nearer approach to equality under unpleasant stimuli. The 'extension' temperament shows the opposite results, and the indifferent temperament exhibits proportions more nearly those given in the above table.

Temperamental differences then work together with the other special tendencies mentioned above in modifying the tendency to contract under disagreeable and to expand under agreeable stimuli. While, therefore, this latter is clearly established by this research as a real and strong tendency, it is at the same time shown to be only one tendency acting among many.