Walter B. Cannon, "The James-Lange theory of emotions: A critical examination and an alternative theory," 1927, *39*, 106–124.

Walter Cannon's article on the James-Lange theory of emotions was an attack on the fundamental notions of emotion held by most psychologists since its postulation by William James in 1884 and by C. G. Lange in 1885. In this classic study, Cannon analyzes the assumption and premises of the James-Lange theory and offers perhaps the best criticism of that position. Cannon then goes on to postulate his own theory of emotion. Cannon held that the viscera and the innervation of muscles were not the sources for the qualities of emotion. He held that emotions are derived from subcortical centers. Cannon's theory, which developed from these beginnings, came to replace the James-Lange theory in most textbooks.

THE JAMES-LANGE THEORY OF EMOTIONS: A CRITICAL EXAMINATION AND AN ALTERNATIVE THEORY*

By WALTER B. CANNON, Harvard University

In his introduction to the reprinting of the classic papers by James and Lange, Dunlap[1] declares that their theory of emotions as organic processes "has not only become so strongly entrenched in scientific thought that it is practically assumed today as the basis for the study of the emotional life, but has also led to the development of the hypothesis of reaction or response as the basis of all mental life." And Perry[2] has written, "This famous doctrine is so strongly fortified by proof and so repeatedly confirmed by experience that it cannot be denied substantial truth. In spite of elaborate refutation it shows no signs of obsolescence." With some trepidation, therefore, one ventures to criticise a view of the nature of emotions which has proved so satisfactory as a means of interpreting affective experience and which has commended itself so generally to psychologists. There are now at hand, however, pertinent physiological facts which were not available when James and Lange developed their ideas and which should be brought to bear on those ideas, and there are alternative explanations of affective experience which should be considered, before the James-Lange theory is granted basal claims in this realm of psychology.

James first presented his view in 1884, Lange's monograph appeared in Danish in 1885. The cardinal points in their respective ideas of the nature of emotions are so well known that for purposes of comment only brief references need be made to them. James' theory may be summarized, in nearly his own terms, as follows. An object stimulates one or more sense organs; afferent impulses pass to the cortex and the object is perceived; thereupon currents run down to muscles and viscera and alter them in complex ways; afferent impulses from these disturbed organs course back to the cortex and when there perceived transform the "object-simply-apprehended" to the "object-emotionally-felt." In other words, "the feeling of the bodily changes as they occur is the emotion—the common sensational,

*This paper is from the Laboratory of Physiology, Harvard Medical School.
[1]W. James and C. G. Lange, *The Emotions*, 1922.
[2]R. B. Perry, *General Theory of Value*, 1926, 295.

associational and motor elements explain all."[3] The main evidence cited for the theory is that we are aware of the tensions, throbs, flushes, pangs, suffocations—we feel them, indeed, the moment they occur—and that if we should take away from the picture of a fancied emotion these bodily symptoms, nothing would be left.

According to Lange[4] stimulation of the vasomotor center is "the root of the causes of the affections, however else they may be constituted." "We owe all the emotional side of our mental life," he wrote, "our joys and sorrows, our happy and unhappy hours, to our vasomotor system. If the impressions which fall upon our senses did not possess the power of stimulating it, we would wander through life unsympathetic and passionless, all impressions of the outer world would only enrich our experience, increase our knowledge, but would arouse neither joy nor anger, would give us neither care nor fear." Since we are unable to differentiate subjectively between feelings of a central and peripheral origin, subjective evidence is unreliable. But because wine, certain mushrooms, hashish, opium, a cold shower, and other agencies cause physiological effects which are accompanied by altered states of feeling, and because abstraction of the bodily manifestations from a frightened individual leaves nothing of his fear, the emotion is only a perception of changes in the body. It is clear that Lange had the same conception as James, but elaborated it on a much narrower basis—on changes in the circulatory system alone.

A Consideration of the Visceral Factors

The backflow of impulses from the periphery, on which James relied to account for the richness and variety of emotional feeling, was assumed to arise from all parts of the organism, from the muscles and skin as well as the viscera. To the latter, however, he inclined to attribute the major rôle—on "the visceral and organic part of the expression," he wrote, "it is probable that the chief part of the felt emotion depends."[5] We may distinguish, therefore, his two sources of the afferent stream. We shall first consider critically the visceral source. In connection therewith we shall comment on Lange's idea that the vasomotor center holds the explanation of emotional experience.

---

[3] James, *op. cit.*, 123. [4] Lange, *op. cit.*, 73. [5] James, *op. cit.*, 116

(*1*) *Total separation of the viscera from the central nervous system does not alter emotional behavior.* Sherrington[6] transected the spinal cord and the vagus nerves of dogs so as to destroy any connection of the brain with the heart, the lungs, the stomach and the bowels, the spleen, the liver and other abdominal organs—indeed, to isolate all the structures in which formerly feelings were supposed to reside. Recently Cannon, Lewis and Britton[7] have succeeded in keeping cats in a healthy state for many months after removal of the entire sympathetic division of the autonomic system, the division which operates in great excitement. Thus all vascular reactions controlled by the vasomotor center were abolished; secretion from the adrenal medulla could no longer be evoked; the action of the stomach and intestines could not be inhibited, the hairs could not be erected, and the liver could not be called upon to liberate sugar into the blood stream. These extensively disturbing operations had little if any effect on the emotional responses of the animals. In one of Sherrington's dogs, having a "markedly emotional temperament," the surgical reduction of the sensory field caused no obvious change in her emotional behavior; "her anger, her joy, her disgust, and when provocation arose, her fear, remained as evident as ever." And in the sympathectomized cats all superficial signs of rage were manifested in the presence of a barking dog—hissing, growling, retraction of the ears, showing of the teeth, lifting of the paw to strike—*except* erection of the hairs. Both sets of animals behaved with full emotional expression in all the organs still connected with the brain; the only failure was in organs disconnected. The absence of reverberation from the viscera did not alter in any respect the appropriate emotional display; its only abbreviation was surgical.

As Sherrington has remarked, with reference to his head-and-shoulder dogs, it is difficult to think that the perception initiating the wrathful expression should bring in sequel angry conduct and yet have been impotent to produce "angry feeling."

At this point interpretations differ. Angell[8] has argued that Sherrington's experiments afford no evidence that visceral sensation plays no part in the emotional psychosis, and further that they do not

[6] C. S. Sherrington, Experiments on the value of vascular and visceral factors for the genesis of emotion, *Proc. Roy. Soc.*, 66, 1900, 397.

[7] W. B. Cannon, J. T. Lewis and S. W. Britton, The dispensability of the sympathetic division of the autonomic system, *Boston Med. and Surg. J.*, 197, 1927, 514.

[8] J. R. Angell, A reconsideration of James's theory of emotion in the light of recent criticisms, *Psychol. Rev.*, 23, 1916, 259.

prove that the psychic state, "emotion," precedes its "expression." And Perry[9] has declared that whether in the absence of sensations from the organs surgically isolated, the emotion is *felt* remains quite undecided.

It must be admitted, of course, that we have no real basis for either affirming or denying the presence of "felt emotion" in these reduced animals. We have a basis, however, for judging their relation to the James-Lange theory. James attributed the chief part of the felt emotion to sensations from the viscera, Lange attributed it wholly to sensations from the circulatory system. Both affirmed that if these organic sensations are removed *imaginatively* from an emotional experience nothing is left. Sherrington and Cannon and his collaborators varied this procedure by removing the sensations *surgically*. In their animals all visceral disturbances through sympathetic channels—the channels for nervous discharge in great excitement—were abolished. The possibility of return impulses by these channels, and in Sherrington's animals by vagus channels as well, were likewise abolished. According to James's statement of the theory the felt emotion should have very largely disappeared, and according to Lange's statement it should have wholly disappeared (without stimulation of our vasomotor system, it will be recalled, impressions of the outer world "would arouse neither joy nor anger, would give us neither care nor fear"). The animals *acted*, however, insofar as nervous connections permitted, with no lessening of the intensity of emotional display. In other words, operations which, in terms of the theory, largely or completely destroy emotional feeling, nevertheless leave the animals behaving as angrily, as joyfully, as fearfully as ever.

(*2*) *The same visceral changes occur in very different emotional states and in non-emotional states.* The preganglionic fibers of the sympathetic division of the autonomic system are so related to the outlying neurones that the resulting innervation of smooth muscles and glands throughout the body is not particular but diffuse.[10] At the same time with the diffuse emission of sympathetic impulses adrenin is poured into the blood. Since it is thereby generally distributed to all parts and has the same effects as the sympathetic impulses wherever it acts, the humoral and the neural agents cooperate in producing diffuse effects. In consequence of these arrange-

[9]Perry, *op. cit.*, 298.
[10]Cannon, *Bodily Changes in Pain, Hunger, Fear and Rage*, 1915, 26.

ments the sympathetic system goes into action as a unit—there may be minor variations as, for example, the presence or absence of sweating, but in the main features integration is characteristic.

The visceral changes wrought by sympathetic stimulation may be listed as follows: acceleration of the heart, contraction of arterioles, dilatation of bronchioles, increase of blood sugar, inhibition of activity of the digestive glands, inhibition of gastro-intestinal peristalsis, sweating, discharge of adrenin, widening of the pupils and erection of hairs. These changes are seen in great excitement under any circumstances. They occur in such readily distinguishable emotional states as fear and range.[11] Fever[12] and also exposure to cold[13] are known to induce most of the changes—certainly a faster heart rate, vasoconstriction, increased blood sugar, discharge of adrenin and erection of the hairs. Asphyxia at the stimulating stage evokes all the changes enumerated above, with the possible exception of sweating. A too great reduction of blood sugar by insulin provokes the "hypoglycemic reaction"—characterized by pallor, rapid heart, dilated pupils, discharge of adrenin, increase of blood sugar and profuse sweating.[14]

In this group of conditions which bring about in the viscera changes which are typical of sympathetic discharge are such intense and distinct emotions as fear and rage, such relatively mild affective states as those attending chilliness, hypoglycemia and difficult respiration, and such a markedly different experience as that attending the onset of fever. As pointed out earlier by Cannon[15] the responses in the viscera seem too uniform to offer a satisfactory means of distinguishing emotions which are very different in subjective quality. Furthermore, if the emotions were due to afferent impulses from the viscera, we should expect not only that fear and rage would feel alike but that chilliness, hypoglycemia, asphyxia, and fever should feel like them. Such is not the case.

---

[11]Cannon, *op. cit.*, 277.

[12]Cannon and J. R. Pereira, Increase of adrenal secretion in fever, *Proc. Nat. Acad. Sci.*, 10, 1924, 247.

[13]Cannon, A. Querido, S. W. Britton and E. M. Bright, The rôle of adrenal secretion in the chemical control of body temperature, *Amer. J. Physiol.*, 79, 1927, 466.

[14]Cannon, M. A. McIver and S. W. Bliss, A sympathetic and adrenal mechanism for mobilizing sugar in hypoglycemia, *Amer. J. Physiol.*, 69, 1924, 46.

[15]Cannon, *op. cit.*, 280.

In commenting on this criticism of the James-Lange theory Angell[16] admits that there may be a considerable matrix of substantially identical visceral excitement for some emotions, but urges that the differential features may be found in the extra-visceral disturbances, particularly in the differences of tone in skeletal muscles. Perry[17] likewise falls back on the conformation of the proprioceptive patterns, on the "motor set" of the expression, to provide the distinctive elements of the various affective states. The possible contribution of skeletal muscles to the genesis of the felt emotion will be considered later. At present the fact may be emphasized that Lange derived no part of the emotional psychosis from that source; and James attributed to it a minor rôle—the chief part of the felt emotion depended on the visceral and organic part of the expression.

(*3*) *The viscera are relatively insensitive structures.* There is a common belief that the more deeply the body is penetrated the more sensitive does it become. Such is not the fact. Whereas in a spinal nerve trunk the sensory nerve fibers are probably always more numerous than the motor, in the nerves distributed to the viscera the afferent (sensory) fibers may be only one-tenth as numerous as the efferent.[18] We are unaware of the contractions and relaxations of the stomach and intestines during digestion, of the rubbing of the stomach against the diaphragm, of the squeezing motions of the spleen, of the processes in the liver—only after long search have we learned what is occurring in these organs. Surgeons have found that the alimentary tract can be cut, torn, crushed or burned in operations on the unanesthetized human subject without evoking any feeling of discomfort. We can feel the thumping of the heart because it presses against the chest wall, we can also feel the throbbing of blood vessels because they pass through tissues well supplied with sensory nerves, and we may have abdominal pains but apparently because there are pulls on the parietal peritoneum.[19] Normally the visceral processes are extraordinarily undemonstrative. And even when the most marked changes are induced in them, as when adrenalin acts, the results, as we shall see, are sensations mainly attributable to effects on the cardiovascular system.

[16]Angell, *op. cit.*, 260.
[17]Perry, *op. cit.*, 300.
[18]J. N. Langley and H. K. Anderson, The constituents of the hypogastric nerves, *J. Physiol.*, 17, 1894, 185.
[19]K. G. Lennander *et al*, Abdominal pains, especially in ileus, *J. Amer. Med. Assoc.*, 49, 1907, 836 (see also p. 1015).

(4) *Visceral changes are too slow to be a source of emotional feeling.* The viscera are composed of smooth muscle and glands—except the heart, which is modified striate muscle. The motions of the body with which we are familiar result from quick-acting striate muscle, having a true latent period of less than 0.001 sec. Notions of the speed of bodily processes acquired by observing the action of skeletal muscle we should not apply to other structures. Smooth muscle and glands respond with relative sluggishness. Although Stewart[20] found that the latent period of smooth muscle of the cat was about 0.25 sec., Sertoli[21] observed that it lasted for 0.85 sec. in the dog and 0.8 sec. in the horse. Langley[22] reported a latent period of 2 to 4 secs. on stimulating the *chorda tympani* nerve supply to the submaxillary salivary gland; and Pawlow[23] a latent period of about 6 *minutes* on stimulating the vagus, the secretory nerve of the gastric glands. Again, Wells and Forbes[24] noted that the latent period of the psychogalvanic reflex (in man), which appears to be a glandular phenomenon, was about 3 secs.

In contrast to these long delays before peripheral action in visceral structures barely starts are the observations of Wells;[25] he found that the latent period of affective reactions to pictures of men and women ended not uncommonly within 0.8 sec. More recent studies with odors as stimuli have yielded a similar figure (personal communication). According to the James-Lange theory, however, these affective reactions result from reverberations from the viscera. But how is that possible? To the long latent periods of smooth muscles and glands, cited above, there must be added the time required for the nerve impulses to pass from the brain to the periphery and thence back to the brain again. It is clear that the organic changes could not occur soon enough to be the occasion for the appearance of affective states, certainly not the affective states studied by Wells.

[20]C. C. Stewart, Mammalian smooth muscle—The cat's bladder, *Amer. J. Physiol.*, 4, 1900, 192.

[21]E. Sertoli, Contribution à la physiologie générale des muscles lisses, *Arch. ital. de biol.*, 3, 1883, 86.

[22]J. N. Langley, On the physiology of the salivary secretion, *J. Physiol.*, 10, 1889, 300.

[23]J. P. Pawlow and E. O. Schumowa-Simanowskaja, Die Innervation der Magendrüsen beim Hunde, *Arch. f. Physiol.*, 1895, 66.

[24]F. L. Wells and A. Forbes, On certain electrical processes in the human body and their relations to emotional reactions, *Arch. Psychol.*, 2, 1911, No. 16, p. 8.

[25]Wells, Reactions to visual stimuli in affective settings, *J. Exper. Psychol.*, 8, 1925, 64.

(5) *Artificial induction of the visceral changes typical of strong emotions does not produce them.* That adrenin, or the commercial extract of the adrenal glands, "adrenalin," acts in the body so as to mimic the action of sympathetic nerve impulses has already been mentioned. When injected directly into the blood stream or under the skin it induces dilatation of the bronchioles, constriction of blood vessels, liberation of sugar from the liver, stoppage of gastro-intestinal functions, and other changes such as are characteristic of intense emotions. If the emotions are the consequence of the visceral changes we should reasonably expect them, in accordance with the postulates of the James-Lange theory, to follow these changes in all cases. Incidental observations on students who received injections of adrenalin sufficiently large to produce general bodily effects have brought out the fact that no specific emotion was experienced by them—a few who had been in athletic competitions testified to feeling "on edge," "keyed up," just as before a race.[26] In a careful study of the effects of adrenalin on a large number of normal and abnormal persons Marañon[27] has reported that the subjective experiences included sensations of precardial or epigastric palpitation, of diffuse arterial throbbing, of oppression in the chest and tightness in the throat, of trembling, of chilliness, of dryness of the mouth, of nervousness, malaise and weakness. Associated with these sensations there was *in certain cases* an indefinite affective state coldly appreciated, and without real emotion. The subjects remarked, "I feel as if afraid," "as if awaiting a great joy," "as if moved," "as if I were going to weep without knowing why," "as if I had a great fright yet am calm," "as if they are about to do something to me." In other words, as Marañon remarks, a clear distinction is drawn "between the perception of the peripheral phenomena of vegetative emotion (*i.e.* the bodily changes) and the psychical emotion proper, which does not exist and which permits the subjects to report on the vegetative syndrome with serenity, without true feeling." In a smaller number of the affected cases a real emotion developed, usually that of sorrow, with tears, sobs and sighings. This occurs, however, "only when the emotional predisposition of the patient is very marked," notably in hyperthyroid cases. In some in-

[26]F. W. Peabody, C. C. Sturgis, E. M. Tompkins and J. T. Wearn, Epinephrin hypersensitiveness and its relation to hyperthyroidism, *Amer. J. Med. Sci.*, 161, 1921, 508, (also personal communication from J. T. Wearn).

[27]G. Marañon, Contribution à l'étude de l'action émotive de l'adrenaline, *Rev. franç. d'endocrinol.*, 2, 1924, 301.

stances Marañon found that this state supervened only when the adrenalin was injected after a talk with the patients concerning their sick children or their dead parents. In short, only when an emotional mood already exists does adrenalin have a supporting effect.

From the evidence adduced by Marañon we may conclude that adrenalin induces in human beings typical bodily changes which are reported as sensations, that in some cases these sensations are reminiscent of previous emotional experiences but do not renew or revive those experiences, that in exceptional cases of preparatory emotional sensitization the bodily changes may tip the scales towards a true affective disturbance. These last cases are exceptional, however, and are not the usual phenomena as James and Lange supposed. In normal conditions the bodily changes, though well marked, do not provoke emotion.

The numerous events occurring in the viscera in consequence of great excitement, as detailed by Cannon,[28] have been interpreted as supporting the James-Lange theory.[29] From the evidence presented under the five headings above it should be clear that that interpretation is unwarranted. Since visceral processes are fortunately not a considerable source of sensation, since even extreme disturbances in them yield no noteworthy emotional experience, we can further understand now why these disturbances cannot serve as a means for discriminating between such pronounced emotions as fear and rage, why chilliness, asphyxia, hyperglycemia and fever, though attended by these disturbances, are not attended by emotion, and also why total exclusion of visceral factors from emotional expression makes no difference in emotional behavior. It is because the returns from the thoracic and abdominal "sounding-board," to use James' word, are very faint indeed, that they play such a minor rôle in the affective complex. The processes going on in the thoracic and abdominal organs are truly remarkable and various; their value to the organism, however, is not to add richness and flavor to experience, but rather to adapt the internal economy so that in spite of shifts of outer circumstance the even tenor of the inner life will not be profoundly disturbed.

---

[28]Cannon, *op. cit.*, 184.

[29]G. Humphrey, *The Story of Man's Mind*, 1923, 211.

A Consideration of the Postural Factors

In his discussion of the cerebral processes accompanying emotion, James[30] argued that either there were special centers for them or they occurred in the ordinary motor and sensory centers of the cortex. And if in the ordinary centers, according to his postulate, the processes would resemble the ordinary processes attending sensation. Only that and full representation of each part of the body in the cortex would be needed to provide a scheme capable of representing the *modus operandi* of the emotions. Object—sense organ—cortical excitation—perception—reflexes to muscle, skin and viscus—disturbances in them—cortical excitation by these disturbances—perceptions of them added to the original perceptions; such are the occurrences which result in the "object-emotionally-felt." The strict alternative, however, of cortical processes *or* special centers we need not accept. There may be cortical processes *and* special centers. Whether such is the arrangement we may now consider.

(*1*) *Emotional expression results from action of subcortical centers.* In a paper published in 1887 Bechterev[31] argued that emotional expression must be independent of the cortex because at times the expression cannot be inhibited (*e.g.* laughing from tickle, grinding the teeth and crying from pain), because visceral changes occur which are beyond control, and because it is seen just after birth before cortical management is important. Furthermore, he reported that after removing the cerebral hemispheres from various kinds of animals appropriate stimulations would evoke corresponding responses of an affective character. Noxious stimuli would cause the hemisphereless cats to snarl, the dogs to whine, to show their teeth and to bark; gentle stimuli (stroking the back) would cause the cats to purr and the dogs to wag their tails. Since these effects disappeared when the optic thalamus was removed, he drew the conclusion that it plays a predominant rôle in emotional expression.

In 1904 Woodworth and Sherrington[32] proved that many of the physiological phenomena of great excitement would appear in cats from which the thalamus had been wholly removed by section of the brain stem at the mesencephalon. Strong stimulation of an afferent

[30] James, *op. cit.*, 123.

[31] W. Bechterev, Die Bedeutung der Sehhügel auf Grund von experimentellen und pathologischen Daten, *Virchow's Archiv*, 110, 1887, 102, 322.

[32] R. S. Woodworth and C. S. Sherrington, A pseudaffective reflex and its spinal path, *J. Physiol.*, 31, 1904, 234.

nerve was required to evoke the "pseudaffective" responses. Although these observations tended to lessen the importance of the thalamus as a center, recent experiments have again emphasized its dominance. In 1925 Cannon and Britton[33] described a pseudaffective preparation—a cat decorticated under ether anesthesia—which on recovery displayed spontaneously the complete picture of intense fury. Further study by Bard (work still unpublished) showed that this sham rage continued after ablation of all the brain anterior to the diencephalon. Only when the lower posterior portion of the thalamic region was removed did the extraordinary activities of the preparation subside. These results clearly point to the thalamus as a region from which, in the absence of cortical government, impulses are discharged which evoke an extreme degree of "emotional" activity, both muscular and visceral.

The evidence just cited is confirmed by observations on human beings. As has been pointed out elsewhere[34] when the cortical processes are abolished by anesthesia, emotional display may be most remarkable. During the early (excitement) stage of ether anesthesia, for example, there may be sobbing as in grief, or laughter as in joy, or lively and energetic aggressive actions as in rage. The surgeon may open the chest or perform other operations of equal gravity, while the patient is pushing, pulling, shouting and muttering; a few minutes later the conscious patient will testify that he has been wholly unaware of what has happened. It is when "laughing gas" has set aside the cortical functions that the subjects laugh and weep. Similar release of the mechanisms for emotional expression is indicated in the depression of cortical activity during acute alcoholism. In all these conditions the drug acts first as a depressant on the highly sensitive cells of the cortex, and thus lessens or temporarily destroys their control of lower centers; only when the drug becomes more concentrated does it depress also the lower centers; but before that stage is reached the lower centers, released from the cortical dominance as in the surgically decorticated animals, show forth their functions in free play.

Consistent with the experimental and pharmacological evidence is the evidence derived from pathological cases. In certain forms of

[33]Cannon and S. W. Britton, Pseudaffective medulliadrenal secretion, *Amer. J. Physiol.*, 72, 1925, 283.

[34]Cannon, Neural basis for emotion expression, *Wittenberg Symposium on Feelings and Emotions*, 1927.

hemiplegia the patients may be incapable of moving the face on the paralyzed side; if suddenly they are affected by a sorrowful or joyous emotion, however, the muscles, unresponsive to voluntary control, spring into action and give both sides of the face the expression of sadness or gaiety.[35] These cases occur when the motor tract is interrupted subcortically and the optic thalamus is left intact. The opposite of this condition is seen in unilateral injury of the thalamus. A patient described by Kirilzev[36] moved symmetrically both sides of his face at will, but when he laughed in fun or made a grimace in pain the right side remained motionless; at autopsy a tumor was found in the center of the left optic thalamus. This localization of the central neural apparatus for the expressions of pleasure and pain has interesting relations to emotive phenomena commonly seen in so-called "pseudo-bulbar palsy." In such cases there is usually a bilateral facial paralysis, with one side slightly more involved than the other. Voluntary pursing of the lips as in whistling, or wrinkling of the forehead, or making a grimace may be impossible. The intractable facial muscles, however, function normally in laughing or crying, scowling or frowning. These well-executed expressions come in fits and are uncontrollable and prolonged. One patient is described who started laughing at 10:00 o'clock in the morning and continued with few pauses until 2:00 in the afternoon! Tilney and Morrison,[37] who have reported on 173 recorded cases of the disease, found such fits of crying and laughing in seventeen percent of the cases, crying alone in sixteen percent, and laughing alone in fifteen percent. The fits appear as a rule without any of the usual provocations and most frequently are inopportune. The patient may have all the appearances of being convulsed with laughter, yet may not experience any of the feeling which the motions of face and body indicate. Such cases are attributed by Brissaud[38] to lesions of a special part of the cortico-thalamic tract which free a portion of the thalamus from the cortical check. It seems probable, as later evidence will suggest, that afferent thalamo-cortical tracts are also defective. Finally, cases of "narcolepsy" are known in which emotional expression is nearly nil; gibes and insults which enrage or infuriate the normal

[35]G. Roussy, *La couche optique*, 1907, 31.
[36]S. Kirilzev, Cases of affections of the optic thalamus (Russian). Reviewed in *Neurologisches Centralblatt*, 10, 1891, 310.
[37]F. Tilney and J. F. Morrison, Pseudo-bulbar palsy clinically and pathologically considered, *J. Ment. and Nerv. Diseases*, 39, 1912, 505.
[38]E. Brissaud, *Leçons cliniques*, 1894.

person are usually quite without effect. In some of these cases, examined *post-mortem*, were found tumors on the under side of the diencephalon, often affecting the whole hypothalamus.

All these observations, experimental and clinical, consistently point to the optic thalamus as a region in which resides the neural organization for the different emotional expressions. The section in James' discussion, headed "No Special Brain Centres for Emotion" must be modified in the light of this accumulated information. The cortex at one end of the nerve paths as a reflex surface and the peripheral organs at the other end as a source of return impulses make too simple an arrangement. Between the cortex and the periphery lies the diencephalon, an integrating organ on the emotive level, a receiving and discharging station, that on proper stimulation is capable of establishing in stereotyped forms the facies and bodily postures typical of the various affective states. That all afferent paths leading towards the cortex have relays in the diencephalon is a fact of great significance in explaining the nature of emotions.

(*2*) *Thalamic processes are a source of affective experience.* The relaying of all sensory neurones in some part of the optic thalamus has been stressed by Head[39] in his important clinical studies. He and Holmes[40] attributed to this region a sort of consciousness, an "awareness." The effect of anesthesia in abolishing consciousness while leaving emotional expression (thalamic in origin) undisturbed would seem to contradict this view. But even if consciousness is associated only with events in cortical neurones, the important part played by thalamic processes is little disturbed thereby. The relays of sensory channels in the thalamus and the evidence that disturbances in that region are the occasion for intensely affective sensations are all that we need for understanding its relation to the nature of emotions.

Head[41] has cited numerous cases of unilateral lesions in the thalamic region in which there is a marked tendency to react excessively to affective stimuli; pin pricks, painful pressure, excessive heat or cold, all produce more distress on the damaged than on the normal side of the body. Agreeable stimuli also are felt keenly on the

[39]H. Head, Release of function in the nervous system, *Proc. Roy. Soc.*, 92B, 1921, 184.

[40]Head and G. Holmes, Sensory disturbances from cerebral lesions, *Brain*, 34, 1911, 109.

[41]Head, *Studies in Neurology*, 1920, II, 620.

damaged side; warmth stimuli may evoke intense pleasure, attended by signs of enjoyment on the face and exclamations of delight. Again, affective stimuli, such as the playing of music and the singing of hymns, may arouse such increased emotional feeling on the damaged side that they may be intolerable. Affective conscious states have an influence on the damaged side similar to stimuli from the surface receptors. This extravagant influence of affective stimuli, whether from above or below, Head attributed to release of the thalamus from cortical inhibition. It is not an irritative effect, he argued, because it persists for long periods, well after all the disturbances due to the injury have subsided. And since the affective states are increased when the thalamus is freed from cortical control, Head's conclusion is that the essential thalamic center is mainly occupied with the affective side of sensation.

We are now in a position to consider the evidence that the positions and tensions of skeletal muscle make the differentia of emotion. It will be recalled that, although James belittled this element in his theory, his supporters have stressed it, especially since the visceral element proved inadequate (see p. 110). The thalamic cases provide a means of testing the contribution from skeletal muscles, for the feeling-tone of a sensation is a product of thalamic activity, and the fact that a sensation is devoid of feeling-tone shows that the impulses which underlie its production make no thalamic appeal.

Head found that his patients reported marked differences in the feeling-tone of different sensations. A tuning fork may have no effect, whereas patriotic music is felt intensely on the damaged side. All thermal stimuli make a double appeal, to the cortex and to the thalamus. Unselected tactile stimuli act similarly. On the other hand, *sensations which underlie the appreciation of posture are entirely lacking in feeling-tone.* Precisely those afferent impulses from muscles and joints which James and his supporters have relied upon to provide the extra-visceral part of the felt-emotion are the impulses which lack the necessary quality to serve the purpose! The quality of emotions is to be found, therefore, neither in returns from the viscera nor in returns from the innervated muscles.

A Theory of Emotion Based on Thalamic Processes

The foregoing discussion has disclosed the fact that the neural arrangements for emotional expression reside in subcortical centers, and that these centers are ready for instant and vigorous discharge

when they are released from cortical restraint and are properly stimulated. Furthermore, the evidence is clear that when these centers are released the processes aroused in them become a source of vivid affective experience. That this experience is felt on only one side in hemiplegic cases is a peculiarly happy circumstance, for in the same individual the influence of the same affective stimulus can be observed under normal conditions and compared with its influence when given free rein.

The neural organization for an emotion which is suggested by the foregoing observations is as follows. An external situation stimulates receptors and the consequent excitation starts impulses towards the cortex. Arrival of the impulses in the cortex is associated with conditioned processes which determine the direction of the response. Either because the response is initiated in a certain mode or figure and the cortical neurones therefore stimulate the thalamic processes, or because on their centripetal course the impulses from the receptors excite thalamic processes, they are roused and ready for discharge. That the thalamic neurones act in a special combination in a given emotional expression is proved by the reaction patterns typical of the several affective states. These neurones do not require detailed innervation from above in order to be driven into action. Being *released* for action is a primary condition for their service to the body —they then discharge precipitately and intensely. Within and near the thalamus the neurones concerned in an emotional expression lie close to the relay in the sensory path from periphery to cortex. We may assume that when these neurones discharge in a particular combination, they not only innervate muscles and viscera but also excite afferent paths to the cortex by direct connection or by irradiation. The theory which naturally presents itself is that *the peculiar quality of the emotion is added to simple sensation when the thalamic processes are roused.*

The theory just suggested appears to fit all the known facts. Its service in explaining these facts may be briefly summarized.

When the thalamic discharge occurs, the bodily changes occur almost simultaneously with the emotional experience. This coincidence of disturbances in muscles and viscera with thrills, excitements or depressions was naturally misleading, for, with the rôle of the thalamus omitted from consideration, the obvious inference was that the peculiar quality of the emotion arose from the peripheral changes. Indeed, that inference is the heart of the James-Lange

theory. The evidence presented in the foregoing pages shows that the inference is ill-founded; the sensations from the peripheral changes, contrary to James' view, are "pale, colorless and destitute of emotional warmth," whereas the thalamic disturbances contribute glow and color to otherwise simply cognitive states. The theory now proposed explains how James and Lange could reasonably make the suggestion which they made. The lack of factual support for their suggestion requires another account of emotional origins. This is provided by the evidence that thalamic processes can add to sensation an aura of feeling.

One of the strongest arguments advanced for the James-Lange theory is that the assumption of an attitude does in fact help to establish the emotional state which the attitude expresses. "Sit all day in a moping posture, sigh, and reply to everything with a dismal voice, and your melancholy lingers." On the contrary, "smooth the brow, brighten the eye, contract the dorsal rather than the ventral aspect of the frame, and speak in a major key, pass the genial compliment, and your heart must be frigid indeed if you do not gradually thaw!" Persons who have tried this advice have testified to its soundness, and have been convinced, therefore, of the truth of the claim that the moods have followed the assumed attitudes. Not all agree, however, that mimicking the outward appearance of an emotion results in the emotion itself. James suggested that the explanation of the discrepancy lay in variations of involvement of the viscera in the artificial expression. As shown above, however, the visceral changes offer only unreliable support for that idea. Again the processes in the thalamus offer a reasonable and simple explanation. As the cases reported by Head have shown, emotions originating from memories and imagination affect more intensely the half-thalamus that has been released from motor control than they affect the normal half. This shows that cortical processes may start thalamic processes and thus arouse an affective return from that portion of the brain. And if in addition a typical emotional attitude is assumed the cortical inhibition of the thalamic neurones with reference to that attitude is abolished so that they have complete release. Under such circumstances the enacted emotion would have reality. On the other hand a purely cortical mimicry of emotional expression without thalamic involvement would be as cold and unaffective as some actors have declared it to be. Whether the emotion

results or not, the thalamic theory of the source of feeling offers a more satisfactory explanation of the effects of assumed postures than does the James-Lange theory.

The cases of release of the thalamus from cortical control on one side, with accompanying ipsilateral intensification of emotional tone, present an insurmountable obstacle to the James-Lange theory. Neither the thoracic nor the abdominal viscera can function by halves, the vasomotor center is a unity, and the patients certainly do not engage in right- or left-sided laughter and weeping. The impulses sent back from the disturbed peripheral organs, therefore, must be bilaterally equal. For explanation of the unsymmetrical feeling we are driven to the organ which is functioning unsymmetrically—*i.e.* the thalamus. It is there that the suggested theory places the source of the emotions.

Another serious difficulty for the James-Lange theory is the evidence that the emotion increases in intensity although the expression is checked. Indeed, there are psychologists who maintain that the emotional state lasts only so long as there is inner conflict between the impulse to act and the hesitant or prudential check on that impulse. So long as the check prevails, however, the organic changes supposed to be the source of the feeling are suppressed. How then can there be felt-emotion? Two answers to this question may be found in James' argument. First he denies the objection. "Refuse to express a passion," he wrote, "and it dies." "Count ten before venting your anger, and its occasion seems ridiculous." On the other hand, he appears to admit that a pent emotion may operate disastrously. "If tears or anger are simply suppressed, whilst the object of grief or rage remains unchanged before the mind, the current which would have invaded the normal channels turns into others, for it must find some outlet of escape. It may then work different and worse effects later on. Thus vengeful brooding may replace a burst of indignation; a dry heat may consume the frame of one who fain would weep, or he may, as Dante says, turn to stone within." There is no intimation that vengeful brooding, being consumed by a dry heat, and turning to stone within are not emotional experiences. Instead of recognizing them as such, however, James stressed the importance of training for repression of emotional display. These rather equivocal and indecisive comments leave untouched the common testimony that intense fear, for example, may be felt, with a pathetic sense of helplessness, before any overt act occurs, and that

scarcely does the appropriate behavior start than the inner tumult begins to subside and the bodily forces are directed vigorously and effectively to serviceable ends. The difficulties of the James-Lange theory in meeting this situation are obvious. If there is a double control of behavior, however, both the inner conflict with its keen emotional accompaniment and the later partial subsidence of feeling are readily explicable. The thalamic patterned processes are inherent in the nervous organization, they are like reflexes in being instantly ready to seize control of the motor responses, and when they do so they operate with great power. They can be controlled, however, by the processes in the cerebral cortex, by processes conditioned by all sorts of previous impressions. The cortex also can control all the peripheral machinery except the viscera. The inhibited processes in the thalamus cannot set the organism in action, except the parts not under voluntary control, but the turmoil there can produce emotions in the usual manner, and possibly with greater violence because of the inhibition. And when the cortical check is released, suddenly the conflict is resolved. The two controls formerly in opposition, are now coöperative. The thalamic neurones, so long as they continue energetically active, provide the condition for the emotion to persist, as James claimed it does, *during* the manifestation. The new theory, therefore, not only avoids the difficulty of the James-Lange theory, but accounts satisfactorily for the poignancy of feeling in the period of paralyzed inaction.

In relation to the double control of the response there is another point that may be emphasized. McDougall[42] has objected to the James-Lange theory on the ground that it is admittedly concerned with the *sensory* aspect of emotion; it pays little or no attention to the always present and sometimes overwhelming *impulsive* aspect of the experience. The localization of the reaction patterns for emotional expression in the thalamus—in a region which, like the spinal cord, works directly by simple automatisms unless held in check—not only accounts for the sensory side, the "felt emotion," but also for the impulsive side, the tendency of the thalamic neurones to discharge. These powerful impulses originating in a region of the brain not associated with cognitive consciousness and arousing therefore in an *obscure* and *unrelated* manner the strong feelings of emotional excite-

[42]W. McDougall, *Outline of Psychology*, 1923, 328.

ment, explain the sense of being seized, possessed, of being controlled by an outside force and made to act without weighing of the consequences.

Finally, the view that thalamic processes add feeling-tone to sensation meets satisfactorily a difficulty which the James-Lange theory encountered in explaining the "subtler emotions." James had to assume indefinite and hypothetical bodily reverberations in order to account for mild feelings of pleasure and satisfaction. If a warm test tube, however, is capable of yielding keen delight on the damaged side in a case of thalamic injury, it is clear that almost any object or situation which can rouse thalamic processes can add affective quality to sensation. And just as a stimulus can become conditioned for a certain motor or glandular response, so likewise a stimulus can be conditioned for the patterns of neurone action in the thalamus. When that stimulus recurs the emotion recurs because the pattern is activated. In such manner we may consider that richness and variety of our emotional life are elaborated.