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On Inhibition

BY

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INTRODUCTION.

Physiological Inhibition.

Inhibition, from the point of view of the physiologist, is a definite, positive process that takes place either in nerve fibers and centers or in the tissue itself. Since the discovery by Edward Weber[1] of the fact that nerve stimulation can produce restraint as well as excitement of an organ, many investigations have been made and many theories proposed to explain it. The general conception of inhibition for the physiologist may be expressed somewhat as follows: Inhibition is arrest of the function of an organ by the action upon it of another organ, or by another function of the same organ, while its power to execute the arrested function is retained, and can manifest itself as soon as the restraining power is removed.[2]

Two processes then are necessary in any phenomenon of inhibition, the process *inhibited* and the process *inhibiting*.

The phenomenon of inhibition may be considered as due to a special process, or as the result arising from the conflict of the different active processes of the body. In the first case there may be a special set of brain centers and nerve fibers whose function is merely that of arresting activity. Or, the brain centers may be arranged in such a way that each center is constantly under the inhibitive influences of higher centers. Or, some characteristic of the tissue itself brings about a condition in which it ceases to respond to stimulation. In the second case there is no process of inhibition as such. If activity is arrested, it is due to the fact that one process gets in the way of another, or that under certain circumstances two processes are opposed and neutralized, neither process being primarily an inhibitive

[1] Wagner's Handwörterbuch, Bd. III., p. 31.

[2] Dr. Meltzer gives the following definition of inhibition: "Inhibition means a temporary diminution or abolition of a vital activity brought about by an external or internal stimulus.". Paper read before the New York Academy of Medicine, February, 1899.

one—*i. e.*, having for its object the arrest of activity. Or the energy of the body may be considered as limited, and that a manifestation of energy in one direction may inhibit its expenditure in any other direction.

Between these conceptions of inhibition there are such vital differences that their indiscriminate use leads to confusion. In physiology, as we have already indicated, the tendency has been to accept the first hypothesis: Inhibition is a definite physiological process taking place for the sole purpose of arresting bodily functions. It has been urged that if it were not for a direct inhibitive influence any central discharge would continue to the point of exhaustion. To account for the fact that this does not take place Dr. Mercier[1] suggests that every nerve center must have its intrinsic tendency to discharge under the control of some extrinsic influence. He does not believe there is any evidence of a special inhibitory center; on the other hand, there is much evidence against it. Every center exerts an inhibitive influence upon lower centers concurrently with its other functions. Therefore every nerve center is subject to, and in turn exercises an inhibiting influence upon, lower centers, thus forming a hierarchy of centers. Blanchi[2] agrees with this explanation. He also thinks that any cortical area may become in turn an inhibiting center for other centers. Ferrier[3] concludes that his experiments point to the frontal lobes as centers of inhibition. But both Blanchi and Monk deny the assertions of Ferrier. They found no loss of control upon removal of the frontal lobes of animals.[4] A monkey whose frontal lobes had been removed by Monk was deterred from picking up a morsel of food by a mere look or gesture of menace. Lewes[5] comes to the same conclusions—*i. e.*, that there are no special centers of inhibition, but that every center may exert an inhibiting influence. Brunton[6] is also of the opinion that special inhibitory centers are unnecessary to explain the

[1] *Brain*, Vol. XI., 1889, p. 361.
[2] *Brain*, 1895, p. 503.
[3] The Functions of the Brain, London, 1876.
[4] *Brain*, 1895.
[5] The Physical Basis of Mind, p. 333.
[6] *Nature*, March 8, 1893.

phenomenon of inhibition. All the above writers, however, consider inhibition as a special process.

There seems to be evidence that the brain has an inhibiting influence upon the spinal cord. The classical experiment upon frogs and lizards is cited by nearly every writer upon the subject. If the brain is removed, the reflexes of the animal increase.[1] They increase proportionately as the layers are removed; and the spinal cord becomes more excitable as its upper part is shaved away. In man lesions in the motor zone seem to cause proportionately greater muscular disturbance than in animals. This would indicate that the subcortical centers are less inhibited by the higher centers as the scale of animal organization descends.[2]

The interference of nerve waves coming from different stimuli, and meeting in the same center, has been proposed as an explanation of inhibition.[3] This theory supposes that under certain conditions nerve impulses may neutralize each other, somewhat in the same manner as light waves. Brunton explains upon this theory the inhibition of the tickling sensation by pressure. If the sole of the foot is touched lightly, violent muscular contractions are caused; but if a firm pressure be applied, muscular activity is inhibited. The following diagram will illustrate.

In slight touches the stimulus is sufficient only to excite the path *S—S—M—M*, which produces the contractions at *M*. When the stimulus is increased by pressure it ascends to a higher center, or cell *S′*, and this cell discharges into *M*. Therefore *M* gets two impulses traversing paths of different lengths, *S—S—M* and *S—S—S′—M*, or *S′—S′—M*. These two wave impulses neutralize each other in *M* in the same way that light waves of different lengths interfere with each other. So the muscular contraction does not take place. If the will power is used to restrain the muscular contraction, the impulse may come

[1] Exner, Erklärung phy. Erscheinungen, p. 70. Baldwin, Handbook of Psy., Feeling and Will, p. 37. Brunton, *Nature*, March 8, 1883. Goltz, Beiträge z. lehre v. d. Functionen d. Nervencentren d. Frosches, Berlin, 1869.

[2] Baldwin, op. cit.

[3] Brunton, *Nature*, March 1, 1883. Wundt, Mechanik der Nerven. Medem, Grundzüge einer exakten Physiologie. Kaiser, Eine Hemmungserscheinung am Nervmuskelpräprat. Zeitschrift f. Biologie, XXVIII., 1892.

down the path from the cortical cell *MB* in the brain, and cause interference in *M*.[1] Wundt admits the possibility of the interference explanation of inhibition by saying that the effect of inhibition takes place when the stimulus waves are so directed

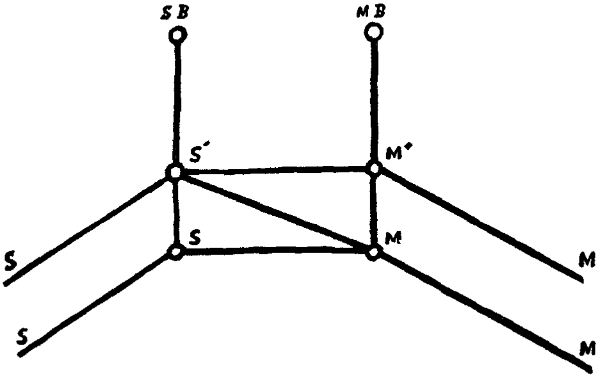


FIG. 1.

S. and *S'*. Sensory cells in spinal cord.
M. and *M'*. Motor " " " "
S. *B*. Sensory cells in brain.
M. *B*. Motor " " "

that they come together in one sensory center, after having traveled paths of different lengths and with different degrees of speed.[2]

Stimuli applied to a very small part of the skin produce a larger reflex than when a greater area is stimulated. Frogs react less when held in the hand, or tied with their bodies against a board, than when suspended by a string from a single point.

If the sciatic nerve on one side of a frog is irritated by a Faradic current, the reaction to a stimulus on the other side is much less; sometimes it is entirely arrested. These facts have been proposed as evidence for the interference theory.

In favor of the belief that there are cortical inhibitive centers there has been some convincing experimental work done. Set-

[1] Brunton's conclusion is that inhibition is not due to special inhibiting centers, but is a relative condition depending upon the length of the path along which the stimulus has to travel and the rate of transmission.

[2] *Physiol. Psy.*, Vol. I., p. 272.

schenow,[1] as early as 1863, asserted that stimulation of the thalami optici and the corpora quadrigemina of the frog increased the reflex time. This statement met with much opposition. Later, however, Sherrington[2] and Hering[3] produced inhibition of the activity of certain muscles by cortical stimulation. Topolanski[4] extended the work of Sherrington, and proved these results. Sherrington asserts that the cortical area for the inhibition of a set of muscles coincides with the area for the contraction of the antagonistic muscles.

Langley[5] has found special inhibitory nerve fibers in the vagus nerve. Pawlow[6] demonstrated that the closing muscles of the anodonta are supplied with two kinds of nerves, nerves that produce contraction and nerves that produce relaxation. Hering proposes the principle involved in his color theory, assimilation and dissimilation, as a theory of inhibition. Dr. Meltzer[7] believes that the process of inhibition is present in every part of the nervous system. Every stimulus calls forth not only activity, but also an inhibition of this activity. All the phenomena of life, then, are manifestations of the resultant of two antagonistic forces. Inhibition therefore is an important and ever-present function of the nervous organism.

The theory that inhibition takes place in the tissue itself considers all nerve stimuli excitory, and that the condition of the tissue determines whether activity or arrest of activity is to take place. According to Gaskell,[8] nerve impulses bring about two processes in the tissue: anabolism and catabolism. The so-called inhibitory nerves are trophic in their function. The building up of any tissue corresponds with the arrest of the function of that tissue.

Dr. Lee[9] thinks that the processes of anabolism and catabol-

[1] Physiologische Studien über Hemmungsnerven, Berlin.

[2] *Jour. of Physiol.*, Vol. XXII., p. 319.

[3] *Pflüger's Archiv*, Bd. 68, p. 222.

[4] *Centralblatt f. Physiol.*, Bd. XII., p. 592.

[5] *Journal of Physiol.*, Vol. XXIII., p. 407.

[6] Wie die Muschel ihre Schaale öffnet, *Pflüger's Archiv*, XXXVII.

[7] Inhibition—paper read before the New York Academy of Medicine, Feb., 1899.

[8] *Journal of Physiol.*, Vol. VII.

[9] In a discussion of Dr. Meltzer's paper.

ism take place at the same time and are excited by the same nerve stimulation. If the catabolic process exceeds the anabolic process, there is activity of the tissue; but if the anabolic process exceeds, then there is inhibition, or arrest of activity.

Heidenhain[1] believes that if a nerve cell is in action, an excitation may inhibit it; but if it were at rest, a like excitation would put it in action.

Piotrowski says that there are many physiological facts which support the theory that inhibition depends upon muscular phenomena, and that it takes place in the muscles themselves.[2]

Psychological Inhibition.

From the foregoing, it is plain that in physiology the term inhibition stands for a definite physiological function taking place either in the tissue itself or in specific nerve centers and fibers. The question now arises as to whether there is any purely psychological process to which we can apply anything like the same conception of inhibition. What does inhibition in psychology mean? Most psychologists have presupposed that its meaning in psychology is practically the same as in physiology. They begin with illustrations of neural inhibition and end with illustrations of inhibition among ideas. The first is a physiological process confined to certain nerve fibers and tissues. The second is a mere logical concept, or else an account of hypothetical powers and entities. Inhibition of ideas often means the mere logical opposition of ideas. The fact that only one of two contradictory statements can be accepted as true does not result from any process of inhibition. It is not even a psychological fact. Yet the concept of inhibition has been applied to it. In fact, inhibition seems to be a general term for the psychologist. He has used it to signify all kinds of opposition. A brief survey of some of the theories of inhibition will show how broad and indefinite the conception is. The opposition of sensations, feelings and ideas was discussed by psychologists long before the term *inhibition* was imported into psychology. The physician Hippokrates said: "duobus doloribus,

[1] *Archives de Physiol.*, Vol. I., p. 333.
[2] *Journal of Physiol.*, Vol. XIV., 1893.

simul abortis, non in eodem loco, vehementier obscurat alterum." Aristotle held that we cannot perceive two distinct sensations at the same time. The sentient soul is indivisible and can exert only a single energy at once. If two stimuli of diverse intensities operate at the same time, either they will fuse[1] or the stronger will render us insensible to the other. When we are occupied with a loud sound, or in deep reflection, or with intense fright, visual objects are often unnoticed.[2] Concerning the suppression of one pleasure by another, he says that any pleasure which is not akin to the operation which it accompanies tends to weaken and obstruct it. If a person is agreeably employed in reading or study, he cannot, if he is a lover of music, persevere in his activity, if he happens to hear a pleasing melody. For the two pleasures not being akin, the stronger overpowers the weaker.[3]

Spinoza: "Whenever anything increases or diminishes, aids or restrains, the ability of the body to act, the idea of that thing increases or diminishes, aids or restrains the power of the mind to think."[4]

From Spinoza's time down to the time of Herbart there seems to have been nothing added to the conception of the inhibition of ideas.

For Herbart, concepts and ideas are expressions of force. They have an existence independent of presentation. They may attract or repel each other. They may enter into combination either in consciousness or on the threshold of consciousness, which combination may expel from consciousness, or prevent from coming into consciousness, opposing ideas and concepts. A suppressed idea is not destroyed. It continues its existence, waiting for an opportunity to present itself.[5]

This repression and conflict of ideas for which Herbart stands is purely a spiritual process in which ideas exert a direct power upon each other.

[1] Aristotle thought that even when they fuse there is a suppression or opposition, for each stimulus appears with a less intensity in the fusion than when alone.

[2] De Sensu et Sensili, VII., p. 447.

[3] Eth. Nic., X., iv., 4.

[4] Ethics, III., ii.

[5] Text-book of Psychology, 1834.

Volkmann follows Herbart very closely. He emphasizes the distinction between the ontological and the psychological aspect of ideas. Inhibition relates only to the latter—*i. e.*, the representation of ideas to consciousness. Inhibition does not imply the non-existence of a once existing idea, but rather its lessened degree of clearness. Ontologically there is no such thing as an inhibited idea. It still strives to get re-presented, but owing to the inhibiting power of ideas already in consciousness it is held at the threshold.[1]

Lotze says: We are wont to regard consciousness as a limited space within which ideas struggle for their places. By a comparison to material forms from whose impenetrability it arises that each one withdraws from the other the space which it itself fills, we smuggle in the conception of the incompatibility of ideas, and, therefore, the pressure which they exert upon each other. But how can relations hold between ideas which make it impossible for certain ones to be known? The obscuration or displacement of ideas is wholly unaffected by the degree of contrast between them in content; nor are the energies by which we conceive opposite concepts opposed in themselves. Concerning the limitations of consciousness, it may be said that we may apprehend many things at the same time if the relations between them are conscious. Only for an unconnected throng has consciousness no room. In place of an abiding contrast between ideas which determines the force with which they repel or attract one another, we would put a degree of affinity which is determined anew at every instant of consciousness. This affinity has for its basis the interest which certain ideas have to the total state of consciousness.[2]

Bain says that if two ideas point in opposite directions they are liable to neutralize one another's efficiency, for since in association ideas assist each other, this implies the power of resisting. Ideas which are not in harmony with existing emotions do not come to consciousness. When several lines of suggestion are open the absence of an additional link in any one of

[1] Lehrbuch der Psychologie, Vol. I., pp. 341–375.

[2] Microcosmus, Book II., pp. 196–219.

them obstructs its progress. On the other hand, the presence of many existing concepts which have found expression in language forms obstructs original thought. The more modern idea of apperception is expressed in a negative way by Bain's theory of obstructive association: The different ways of looking at the world conflict and obstruct each other. The scientific man cannot see the world as the poet does, because his own particular associations stand in the way. If he thinks at all, he must follow them. On the other hand, the poet is never so brilliant as when the trammels of truth are set aside—when the path is cleared for fancy.[1]

Spencer thinks that certain states of consciousness offer great resistance to each other when an attempt is made to put them together. Ex.: The ideas 'hot' and 'ice' will not be united.[2]

Sully: Doubt arrests action; but a strong impulse to act may overcome the doubt. Action is also arrested when it leads to pain, when the action itself is disagreeable, or when it anticipates a disagreeable result. Rivalry of impulses takes place when one is stimulated to take two positive lines of action which are different. Will enters as a determining factor; but it shows an inhibitive as well as an active side. Inhibition is not inactivity, but rather a positive and definite form of activity. Self-control has an inhibitive aspect when we decide not to do a thing.[3] Sully assumes that the higher cortical centers exert an inhibitory influence on the lower centers.

James Ward: The flow of ideas may be interrupted by intrusion of new presentations, by voluntary interference and by conflict of presentations already in the mind. Presentations of opposites with the same local sign is impossible. Since the attention is limited, new presentations draw it off at the expense of old presentations.[4]

Stout: The process of attention shows an inhibitive aspect in that it is a unified process that excludes everything which does

[1] The Senses and the Intellect, p. 597.
[2] Principles of Psy., Vol. 2, Dynamics of Consciousness, p. 444.
[3] The Human Mind, Vol. II., pp. 248–270.
[4] Encyc. Brit.

not belong to the particular system of ideas which holds the attention at any one time. Each mode of the mental process tends to arrest and suppress all others, and is successful in proportion to its intensity and systematic complexity. There is a very compact resistance offered by a highly complex group of processes in systematic union and effective coöperation. When conditions operate to bring about a situation where attention takes disparate directions with equal force the result is mental stupefaction.[1]

Wundt[2] considers inhibition in its psychological aspect as the negative side of the associational process. The direction which association takes necessarily inhibits certain ideas from entering consciousness. Some are free to enter, others are shut out. The strength of inhibition depends upon the intensity of the subject of discourse. When an idea overcomes this inhibitory influence the struggle shows itself in the lengthened reaction time.

Höffding: The cerebrum stands not only in a positive, but also in a negative relation to the lower centers—*i. e.*, it may inhibit as well as excite activity. It subjects the external impulse to a thorough elaboration, and initiates activities independently and in opposition to the excitation of the moment. The will, therefore, has a negative as well as a positive influence.[3] On the other hand, a motive to action may be suppressed by sensations, ideas and feelings which do not fuse with it.[4]

Ribot: Inhibition shows itself in the attention process. Ideas and impressions are in a state of perpetual progression. When the attention fixes itself upon a single idea it does so by a momentary inhibition of all other ideas and impressions. Inhibition then is the negative side of the conscious process, manifesting itself in suppressing the useless conscious states.[5]

Binet: Negation of one representation by another involves two

[1] Analytic Psychology, Vol. I., p. 194. For Stout's theory of Negative Apperception, Destructive Apperception, Conflict of Mental Systems, see Vol. II., pp. 3, 14c.

[2] *Physiol. Psy.*, Vol. II., pp. 481, 506.

[3] Outlines of Psy., Eng. tr., p. 43.

[4] Ibid., p. 335.

[5] Psy. of Attention, p. 64.

positive representations which are contradictory; *e. g.*, "There are no books upon the table" means that first one thinks of the table *with* books upon it, and then of the table *with no* books upon it. The one representation is inhibited by the other. Fixed ideas inhibit other mental imagery. In illusions the false idea inhibits the true. In general, mental states which do not fall into the same system inhibit each other.[1]

Baldwin: The clearest and most important kind of mental inhibition is that exercised by the will. It is possible by direct force of will to prevent a nervous reaction or a train of thoughts. Inhibition is at its maximum in reactions which involve centers of most complex activity; or, in other terms, it is possible in proportion as the system grows away from a single line of action. The more possibility for diverse action the more inhibition is manifest. Conscious life is a complex of conflicts, repressions and reinforcements among images almost as great as the systems of tensions found in the nervous system. The image of a winged horse is inhibited by that of a real horse, or a fixed idea may exert an inhibitive force over the whole field of consciousness.[2]

James: Any mental process once begun would continue to the point of exhaustion if not inhibited by other processes. This inhibition is to be explained upon psychophysical grounds, and consists in a drainage of the sensory impulses away from the active centers corresponding to the mental process. This drainage brings about a lessened or suspended activity of that special process. One mental process then can inhibit another by appropriating its nervous energy. On the other hand, interference of any mental process by irrelevant sensory stimuli pressing in upon its centers may be inhibited by a drainage of those sensory currents downward into some motor path which is kept open by muscular activity, such as twirling a pencil or fumbling with a watch chain during deep thought. Thus, inhibition is an essential element in cerebral life, which, on the one hand, makes possible the entrance upon the stage of consciousness of only one set of sensations at a time, and so preventing a hopeless jumble;

[1] L'inhibition dans les phénomènes de conscience, *Revue Phil.*, Aug., 1890.

[2] Handbook of Psy., Feelings and Will, pp. 36, 70.

and, on the other hand, provides for the arrest of any mental activity when it has served its purpose.[1]

Ladd: The field of consciousness at any one moment is limited. The selection of objects for this field implies the partial or total exclusion of other objects. The result of this limitation taken in connection with the unity of consciousness is a conflict and inhibition of ideas. But this conception should not be carried into the realm of the unconscious. To determine the inhibitive value and efficiency of ideas not in consciousness is impossible. Why some ideas triumph we do not know. In any complex mental state that is chiefly characterized by ideation the principles both of fusion and of inhibition combine to produce the result. Some tendencies take leading and predominating parts, others get relatively suppressed. The processes of fusion and inhibition go on simultaneously. What tendencies will prevail and what not, may be said to involve the entire past history of the psychical life.[2]

The different views of psychological inhibition expressed in the last few pages may in a general way be classified into five conceptions. The first four consider inhibition as a process entirely psychical.

1. Inhibition as an expression of the power which ideas, as such, exert upon each other: This view looks upon ideas as permanently existing entities persisting independently of their presentation to consciousness, and possessing the power of attracting and repelling each other directly. Inhibition is then the process by virtue of which some ideas are prevented from being presented to the soul because of the repellent force of other ideas either in or upon the threshold of consciousness.

2. Inhibition as obstructive association: Inhibition is the negative side of the associational process. The number of mental elements which can enter the field of consciousness at any one time is limited. What elements do enter is determined by the laws of association. The elements which do not enter are inhibited because the mind is already filled. Another way

[1] Psy., Vol. II., pp. 581–585.

[2] Psy., Descriptive and Explanatory, pp. 252–259.

of putting it is, that certain ideas are of such a nature that they do not fit into the chain of association as well as other ideas, and consequently are inhibited by their own nature.

It is practically the same conception to consider the attention process as the effective factor in determining what shall enter consciousness, and so negatively what shall remain out of consciousness. In either case the point to note is that inhibition is but a name. In fact, according to the above conception, there is no active process for which it stands. It is merely an attitude of the mind taken in considering the active processes of attention and association.

3. Inhibition as logical contradiction: A statement cannot be thought as being both false and true at the same time. This conception, of course, cannot be considered as adequate, nor, indeed, properly one of inhibition.

4. Inhibition as a mode of the will's activity: The will not only excites and directs mental activity, but it checks and controls it. This function is seen most frequently in checking and controlling the movements of the body.

5. Inhibition as a psychophysical phenomenon: This view considers the physiological side of consciousness—*i. e.*, cerebral activity. The activity of nervous energy in certain centers and paths inhibits its use in other centers and paths, and consequently the mental state appropriate to the activity of those centers. The drawing off of nerve currents from certain centers inhibits the continued activity of those centers. Of course, such a conception might be nothing more than the statement of any one of the first four views in coördinate physiological terms.

It is not intended that any psychologist should be set down as holding any one of these conceptions exclusively. But these are the limits within which the conception of inhibition has been applied by psychologists. This conception cannot be said to have any definite or well-defined meaning. Sometimes it is used to designate a purely hypothetical process conceived as taking place between the world of existence and the world of non-existence—*i. e.*, between conscious and so-called unconscious ideas. Sometimes it is a direct fiat of the will. Sometimes it is the mere condition of not being called into existence, as is the case in association. Again, it may be the mere logical contradiction of two statements. Inhibition is a term which has been used to designate all kinds of mental conflict, hesitation and arrest.

So in answer to the question concerning the use of the term in psychology, it seems evident that it does not have the same definite and accepted meaning that is given it in physiology. In this latter science it is now recognized as a definite function of certain nerve fibers. In psychology, on the other hand, it is yet a very general and much used term, including in it the ideas of cessation, opposition and conflict. Logical, and even ontological, conceptions have been mixed up in the views of inhibition. From the nature of the objects of physiology and the objects of psychology we could not expect a paralleled application of the term in the latter science. Physiology deals with material objects wherein physical laws hold. Impenetrability, force and repulsion may very properly be regarded as characteristics of matter; but in what way can they be regarded as properties of ideas, or mental states? This question may be regarded as settled by the general discredit into which those "hideously fabulous performances of the Herbartian Vorstellungen" have fallen. Inhibition, as a process, implies impenetrability, force and consequent repulsion, and, therefore, has definite meaning in psychology only as we approach physiology —*i. e.*, enter the field of psychophysiology. This will be considered more fully later.

There is another consideration which makes against the conception of inhibition in purely spiritual terms. It comes out of the nature of the existence of ideas. The existence of an idea depends upon its presentation. There is no such thing as an unpresented idea. Whatever else it may be before presentation, it is not an idea; nor can it be said to be an idea after it has passed from consciousness. Ideas are not entities which have existence outside of the conscious field; they do not persist like material bodies. The elements of mental states are constantly changing, so that we may say that an idea is different at every instant of its existence. In this sense we may hold that every idea perishes at its presentation. Now to say that an idea is held out of consciousness by ideas in consciousness can have no meaning; for there *are no ideas out of consciousness.* That which is out of consciousness is not an idea, and as such is neither affected nor exerts any influence.[1] Inhibition of ideas by other ideas, then, is a pure abstraction. This consideration holds equally against the view of inhibition which makes it the negative side of association, in so far as this latter process rests upon the assumption that ideas as such affect ideas not yet presented.[2] Even granting the existence of unpresented ideas, it would be a difficult task to explain how ideas *in* consciousness can exert a repellent force upon ideas *outside* of consciousness.

Because, obeying the laws of association, the train of conscious ideas takes one direction rather than another, this can hardly be considered sufficient ground to hold that other *possible* trains of ideas are inhibited. The world of existence cannot be supposed to exert an inhibiting influence upon a world of non-existence. If a child is born a girl, does that fact inhibit its being a boy? But just such conceptions of inhibition have been used by psychologists. James[3] speaks of the 'Law of the Inhibition of Instinct by Habit,' and gives as an illustration of this law the inhibiting influence which the selection and building of a nest have upon the bird's instinct to build nests. Stated more generally: After reacting upon one specimen of a class other specimens do not call forth the reaction. This is an unwarranted use of the term. It is equal to saying that the impulse to build nests is still active after the nest is built, but that it is held in check by a restraining influence. This, however, is not true. The impulse to build the nest is not inhibited; on the other hand, it runs its full course in an unrestrained manner, normally. There is no inhibition. The impulse ceases because *it is not inhibited*, because it has fulfilled its mission undisturbed. *It is an impulse to build one nest, not an impulse to build nests continually.* Animal instincts of this nature are impulses called forth under certain conditions; the conditions

[1] This, of course, does not deny the hypothesis of physical dispositions.

[2] To those who say that this is a mere matter of phraseology, I can suggest only that the use of the term *idea* in two senses leads to confusion. A more careful use of terms is advisable.

[3] Psy., Vol. II., p. 394.

being fulfilled by the realization of the impulses, then they no longer exist. If this were not so, what a smouldering mass of struggling impulses the ordinary animal would be, and what an amount of energy would be consumed in inhibition!

The conception of inhibition which considers certain ideas as opposed in content and, therefore, as excluding each other from the field of consciousness, may mean nothing more than logical opposition. Properly, there is no inhibition involved in this conception; on the other hand, the opposition depends upon the possibility of thinking ideas together, which brings out the relation of opposition. Only when ideas are presented at the same time can opposition exist. Psychologically, opposition in the content of states of consciousness does not bring about suppression; on the other hand, we regard it as one of the laws of association by virtue of which ideas are helped into existence. Opposition in the content of ideas is no more a principle of inhibition than likeness of content. The principle of contradiction is also a logical principle, and is not applicable here.

The inhibition which the will exercises seems to be most effective in the field of bodily movements, especially voluntary acts. Any voluntary movement may be arrested immediately by the will. But within the field of consciousness it does not have an immediate and direct effect. If one attempts to thrust out of consciousness an idea, or an emotion, the attempt serves only to intensify it. The more direct the effort the clearer will the idea become, and the more persistently does it remain. The will is successful in inhibiting mental states only when working through the motor adjustments of the body. If we wish to banish certain thoughts from our mind, we can do so only indirectly by inhibiting, the bodily adjustments which accompany such thoughts. A change of bodily activity tends to bring about a change of mental states.

After this hasty survey of the different conceptions of inhibition I am satisfied that its use in psychology should be confined to psychophysical phenomena. Its use in purely mental terms is either meaningless, or else involves the hypothetical creations of the Herbartian psychology. Almost universally the instances of inhibition cited by the foregoing psychologists involve definite bodily activities, either within the field of sense perception or bodily movements. These instances fall under the following classes:

1. Inhibition of one sensation by another: A faint sound is inhibited by a loud sound; a slight pain by a greater pain.

2. Inhibition of bodily movements by sensation: A sudden sight or sound may inhibit movements of walking, breathing or the action of the heart. Pain may inhibit the movements which cause it.

3. Motor activity may inhibit mental states: Activity in battle may inhibit fear. Motor activity inhibits the feelings of embarrassment. If, when trying to remember a name, some other name very similar is pronounced the first name is inhibited.

4. Emotions may inhibit bodily functions: Shame inhibits the action of the vasomotor muscles. Great dread inhibits the flow of saliva. Great grief inhibits the flow of the blood to the brain.

5. Will may inhibit the voluntary and half-voluntary movements of the body, and, to a certain extent, the involuntary muscles. Some people are able to decrease the activity of the heart at will.

It will be seen that in all the above cases of inhibition there is involved, as has already been stated, distinct and definite physiological activities which are closely connected with mental states. It is within this field of psychophysiology that the conception of inhibition has meaning from the psychological point of view, and inhibition in so far as it concerns psychology must be described and explained in terms of the psychophysical mechanism.

Experimentally I have investigated two phases of inhibition within this field:

(1) Inhibition of one sensation by another.

(2) Inhibition of mental states through suppression of their motor elements.

The next two sections are given to these questions.

BINOCULAR RIVALRY.

If corresponding points of the two retinæ are separately stimulated with two incongruous fields—*i. e.*, fields of sufficient difference to prevent their interpretation as a single field—the phenomenon of binocular rivalry appears.[1] For a time one field presses itself into consciousness, then the other takes its place. In this manner a continual shifting of the fields takes place. If a green glass is held before one eye and a red glass before the other, and the eyes turned toward the sky, the struggle of colors is very readily seen. A simple way of getting rivalry between the two eyes is to close both eyes, cover one of them with the hand and turn the face toward the bright sky. The dark and the light fields will be seen alternately.

The stereoscope affords a convenient means of separating the two fields. If a simple drawing of two perpendicular parallel lines is so placed in the stereoscope that it can be seen by the right eye only, and another drawing of two horizontal parallel lines is placed so that it can be seen by the left eye alone, the cross which results shows at the point of intersection a rivalry of the two sets of lines. For an instant they will appear as in *a*, Fig. 2. The next instant they will appear as in *b*, same figure. The fluctuations will continue indefinitely.

Several explanations of this phenomenon have been offered. Helmholtz was the first investigator who studied binocular rivalry carefully. He concluded that the change of fields is due to a change of attention—*i. e.*, the rivalry is psychical, and not physical. If the attention is held upon one of the fields, it will remain in consciousness to the exclusion of the other field.[2]

[1] Wundt, *Physiol. Psy.*, Vol. II., p. 211. Lectures, tr., pp. 195–210. Hermann, Handbuch d. Physiol., p. 380. Helmholtz, Optik, p. 918. Hering, Beiträge z. Physiol., p. 313. Exner, Entwurf z. e. Physiol. Erk. Psy. Er., p. 72. Fechner, Ueber einige Verhältnisse d. binocularen Sehens, *Abhl. d. k. Sächs. Ges. d. Wiss.*, VII., p. 378. Panum, Physiol. Untersuchungen über das Sehen mit zwei Augen, Du Bois, Reymond's *Archiv*, 1867, p. 63. Woinow, Ueber den Wettstreit d. Sehfelder, *Arch. f. Ophthal.*, XVI., p. 194. Schön, Zum Wettstreit d. Sehfelden, *Klin. Monatsbl. f. Augenheilkdz.*, XIII., p. 356. Axenfeld, Un phénomène de contraste binoculaire, *Arch. Ital. de Biol.*, XII. Chauveau, Sur la théorie de l'antagonisme des champs visuel, *Compt. Rend.*, Vol. 13, p. 439.

[2] Optik., p. 920.

He further states that the rivalry does not depend upon any organic structure or condition of the nervous system,[1] but upon mental conditions. The fact that rivalry does take place is explained by the fact that the attention is ever seeking something

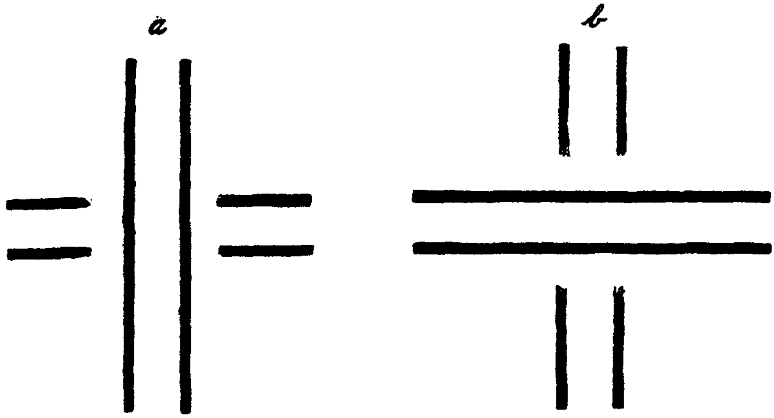


FIG. 2.

new. It does not ordinarily maintain itself in a state of rest, but is constantly changing. If we wish to hold any object in consciousness, we may do so by constantly finding new elements or aspects in it for consciousness. Accordingly, Helmholtz believes that the rivalry between the two retinæ can be controlled at will—*i. e.*, if the attention is held upon one of the two fields by force of will power, that field will remain in consciousness.

Hering[2] and Panum[3] consider that binocular rivalry is due *purely* to physiological conditions. Fechner[4] opposes the attention theory of Helmholtz, and Woinow[5] seems to agree completely with Helmholtz.

Chauveau[6] thinks that the phenomenon of binocular rivalry is central, and not peripheral, as Panum suggests. He proposes the hypothesis, as the physiological basis of the rivalry, that the central cells for corresponding points in the

[1] Ibid.
[2] Zum Lehre von Lichtsinne, pp. 380–385.
[3] *Op. cit.*
[4] *Op. cit.*
[5] *Archiv f. Ophthal.*, Vol. XVI., pp. 194–199.
[6] *Op. cit.*

retinæ are connected with a single optical center, from which visual center the perception of sight arises. When corresponding points of the retinæ are stimulated by the same or like objects the corresponding central cells give the same report to the optical center, and hence there is no conflict; but when corresponding points are stimulated by different objects, then the reports which the single optical center receives conflict and perception is interfered with. In favor of this theory is the fact that parts of the field which fall upon adjacent points of the retinæ do not show rivalry, but are fixed in consciousness, showing that the retina itself does not possess any noticeable functional rhythm similar to the rhythm of binocular rivalry.

St. Witasek[1] reports that he was able, after practice with the stereoscope, to prevent binocular rivalry of different contours. He used the Zöllner figure, the parallel vertical lines for one eye and oblique lines for the other. He was attempting to get the illusion of the Zöllner figure when its parts were combined by means of the stereoscope. At first the illusion did not appear, because, owing to the rivalry, the lines did not appear simultaneously. After continued attempts he claims that he was able to prevent the rivalry, so that both sets of lines were present at the same time, making the completed figure. This prevention of the rivalry is *very remarkable*. No one has reported such a result before. Neither Helmholtz nor Woinow found that they were able to hold *both* fields in their experiments. They believed that by controlling the attention and fixing it upon one field they could exclude the other; but to hold two different fields in consciousness at the same time, under these conditions, is quite another thing. I have been working two years with the stereoscopic combination of different fields, and have been unable to discover any tendency of the kind mentioned. One of my problems during these two years has been just this attempt to control the rivalry, but I have gained absolutely nothing in my ability to do so; nor have any of my subjects been able to prevent the rivalry. The experiments bearing upon this point will be given later.

The object of my experiments was not so much to find an ex-

[1] *Zeitschrift f. Psy.*, Dec. 20, 1898.

planation for binocular rivalry, as to determine what conditions, both subjective and objective, affect it, and to what extent the phenomenon throws light upon the general problem of inhibition.

Apparatus.

The stimuli for the retinæ were red and green squares one centimeter in size. For the greater part of the experiments these two squares were crossed by five black diagonal lines. The lines upon the red field ran from the upper left-hand corner to the lower right-hand corner, while those upon the green field ran from the upper right-hand corner to the lower left-hand corner, so that when the fields were combined in the stereoscope the lines crossed each other at right angles. These fields were placed upon a black cardboard in proper positions for the stereoscope:

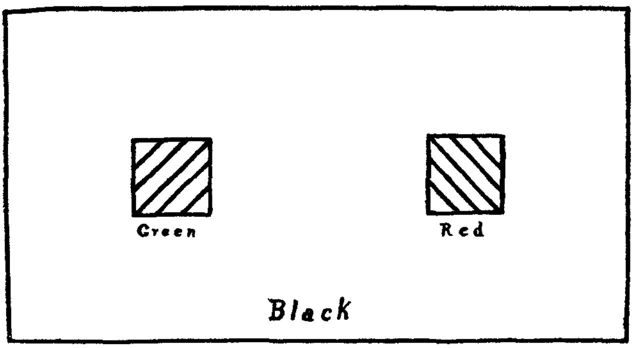


Fig. 3.

When this cardboard was placed in the stereoscope the squares fell upon corresponding points of the retinæ. Red and green backgrounds for the lines were employed merely to aid the subject in determining when the changes in the fields came. If the lines were upon like backgrounds, perception of the exact time the changes occur was more difficult. The colored backgrounds changed in every case with the lines—*i. e.*, the right diagonal lines were always seen upon the red background and the left diagonal lines upon the green. The form of the lines was varied as the conditions of the experiments required. Red and green borders of different widths were prepared, so that the colored backgrounds could be enlarged without extending the lines. These borders were placed around the fields. The light intensities were varied by means of shades and screens.

By means of a second's pendulum a moving field either for both or for one eye was arranged. This was done by fastening cardboard of the required color to the pendulum. This cardboard had upon it the black lines of the first fields, and was of such size that when the pendulum was set in motion a moving colored field with the lines upon it could be seen for all positions of the pendulum, through an opening in a screen. The card for the stereoscope had two square openings, one centimeter in size, cut out of it at the points where the red and green squares of the figure on page 21 are situated. Now if the stereoscope with this card in position were placed in front of the moving cardboard, each eye would be stimulated by a moving colored field, the movement, however, being restricted to the opening in the cardboard in the stereoscope. The rate of movement was regulated by the amplitude of the pendulum. It was an easy matter to arrange a moving field for one eye while the field for the other eye remained stationary.

These arrangements so far admitted only of the use of reflected light. It was found convenient to use transmitted light in some of the experiments. In order to do this the two red and green fields were made of gelatin films of those colors. Lines were made upon them by pasting strips of black paper across them. These lines were the same in number and direction as upon the fields already described. The films were placed in the openings, one centimeter square, of a black cardboard of proper dimensions for the stereoscope. Electric lights, arc and incandescent, placed behind these films gave the various stimuli.

In order to register the length of time each field remained in consciousness a kymograph carrying three writing pens was set up. Two of the pens were connected with two electric keys which were manipulated by the subject; the third pen was connected with a clock and wrote seconds. The kymograph was driven by a small electric motor at a uniform speed of one centimeter per second. The time line upon the records was a check upon the rate of speed. The records were taken upon continuous roll paper. The subject did the recording by pressing the right key when he saw the right field and the left key when he saw the left field.

EXPERIMENTS.[1]

Sec. I. The Effect of Will upon Rivalry.

The question of how far will power is able to control the rivalry of the two retinæ is the subject of this section. The stimuli were the right diagonal lines for the right eye and the left diagonal lines for the left eye. The right diagonal lines in all cases were upon the red background, and the left diagonal lines were upon the green.[2] At each sitting three records were taken: a normal record, a record showing the effect when the subject tried to hold the red field by will power and a record showing the effect when an attempt was made to hold the green field. During the normal record the subject allowed the change of fields to take place without attempting to influence it in any way. In the next two records an attempt was made to hold the fields by fixing the attention upon one of them and by dint of will power see it alone, to the exclusion of the other field. Each record was one hundred seconds long, or the length of time nearest one hundred seconds in which there were an equal number of changes for each of the two fields. The following table gives the results. The second and fourth columns give figures in percents of the whole time of each experiment; *e. g.*, subject 1 normally held the red field 51% of the time, but when he tried to hold it he could do so 70% of the time.

Every subject expressed the opinion at the beginning of the experiment that he could control the fluctuations of the fields. None of them had had any experience with the phenomenon of binocular rivalry.

[1] These experiments were begun in the Harvard laboratory during the year 1897–98, but the major part of the work here reported was done in the Columbia laboratory.

[2] Hereafter these fields will be designated by their colors, viz., red field—green field. The rivalry, however, was between the two sets of lines.

TABLE I.

Subjects.	NORMAL. Per cent. of time seen.	NORMAL. No. of changes.	WILL. Per cent. of time seen.	WILL. No. of changes.
	RED FIELD—RIGHT EYE.			
1	51	33	70	23
2	61	31	76	27
3	53	18	66	17
4	58	18	64	19
5	45	30	61	36
6	52	16	69	16
7	49	57	59	61
8	57	38	73	48
9	49	18	63	24
Av.	53	259	68	280
	GREEN FIELD—LEFT EYE.			
1	49	33	68	40
2	39	31	74	34
3	47	19	50	20
4	42	18	46	17
5	55	30	70	36
6	48	16	56	19
7	51	58	64	58
8	43	39	77	53
9	51	19	58	25
Av.	47	263	63	302

The averages for the red and green fields under normal conditions for six of the above subjects is given in Table II. These averages are from ten normal records taken at different times during the year.[1] All figures are expressed in per cents.

TABLE II.

Subjects.	RED. Av. for 10 Normals.	RED. Av. V.	RED. Max. V.	GREEN. Av. for 10 Normals.	GREEN. Av. V.	GREEN. Max. V.
1	52	2.	4.8	48	2.7	4.4
2	59	4.3	7.2	41	4.2	10.
3	53	1.8	3.1	47	2.1	3.7
4	59	3.	7.3	41	3.	7.4
7	50	1.5	3.5	50	1.	1.9
9	49	2.8	4.	51	1.8	2.5

[1] Each normal was one hundred seconds long.

From Table II. it will be seen that under normal conditions the length of time either field remains in consciousness is fairly constant for each subject.

From Table I. we get the following results:

(1) Each subject was able to increase the length of time a field was seen by fixing the attention upon it.

(2) But the number of fluctuations in the rivalry could not be controlled. The number of changes showed a tendency to increase under effort.

The question of eye movement demands consideration in this experiment. It was noted that during the normal records there was very little, if any, eye movement. At least we can say that it was at a minimum. But whenever any effort was made to hold one of the fields observation revealed the fact that the muscles of the eyes were very active. If it were the red field that the subject was attempting to hold, when it appeared the eyes were constantly moving from one point of the field to another; when it disappeared, and the green field took its place, the muscles of the eyes seemed to relax: for the activity which was so apparent when the red field was in consciousness disappeared with the field; when it appeared again the movement of the eyes was resumed. Each appearance of the red field was accompanied by activity of the eye muscles, while the appearance of the green field was accompanied by inactivity. When the subject attempted to hold the green field, then, the activity accompanied its appearance, and the inactivity the appearance of the other field. This movement of the eyes brought about a change of stimuli, owing to the nature of the fields, as well as an increase in the area of retinal stimulation.

Most of the subjects were not aware of these movements until their attention was called to them. If they were asked to eliminate them, the sense of will effort disappeared. The movements seemed to be a necessary element in the activity of the will power—*i. e.*, if the subject did not make these movements, it did not seem to him that he was trying to hold the field. With naïve subjects it was impossible to eliminate the movements. These movements would invariably appear whenever they were asked to hold one of the fields by force of will. In my own case I was able, after some practice, to hold the attention upon one of the fields without making the eye movements.[1]

The preceding experiments were then made upon myself under the same conditions, except that so far as possible eye movements were eliminated. The eyes were fixed upon the center of the field and held there. Each experiment, as before, was one hundred seconds long.

TABLE III.

	NORMAL.		WILL.	
Experiments.	Per cent. of time seen.	No. of changes.	Per cent. of time seen.	No. of changes.
	RED FIELD—RIGHT EYE.			
1	53	17	51	15
2	55	24	50	22
3	54	24	54	23
	REVERSE—RED FIELD—LEFT EYE.			
4	47	19	48	16
5	44	17	53	17
	GREEN FIELD—LEFT EYE.			
1	—	—	—	—
2	45	24	47	20
3	46	24	46	23
	REVERSE—GREEN FIELD—RIGHT EYE.			
4	53	19	56	16
5	56	17	56	21

Table IV. gives the results of twenty normal experiments made upon myself.

TABLE IV.

	Per cent. of time seen.	Av. V.	Max. V.	Av. No. of changes for 100 sec.
Red.	49.7	2.6	8.	24.
Green.	50.3	2.6	8.	24.

The variations are expressed in per cents.

[1] Movements which are perceptible.

Table III. shows that elimination of the eye movements from the experiment takes away the power which the will seemed to exercise over the length of time either of the fields can be held in consciousness. It should be stated that I acted as subject myself in the first experiments, and obtained the same results as those of the other subjects.

It should be noted also that these results show no exception. All point uniformly in the same direction. The lengthened time, then, which seemed to be due to the will in the first experiments was due rather to eye movements. Now if this be true, re-introduction of the movements ought to give the same results as those in the first experiments. This I have attempted to do in the next experiment. In all the following experiments, except when otherwise stated, the results are taken from my own records.

They have been checked, when possible, by results from other subjects, and they have agreed with them in every case.

Sec. 2. *Eye Movements.*—The conditions of this experiment were the same as in the experiments of Section 1, with the exception that instead of attempting to hold the fields by will power, conscious eye movements were introduced. First, movements in the direction of the lines of the red field—*i. e.*, the middle line was fixated and the eyes moved back and forth along this line. Second, movements in the direction of the lines of the green field.

TABLE V.

Experiments.	Red, per cent. of time seen.	Green, per cent. of time seen.	No. of changes for each field.
	MOVEMENT—RED FIELD.		
1	79	21	18
2	77	23	18
3	73	27	22
	MOVEMENT—GREEN FIELD.		
4	40	60	22
5	40	60	19
6	43	57	20

For normals and variations, see Table IV., Sec. 1.

Another form of eye movement is introduced, if during the experiment the lines upon the fields are counted back and forth. This not only calls for movement of the eyeballs, but brings into activity the apparatus for accommodation as well, in that the counting of each line necessitates fixating it. The eye movement in this experiment is in the opposite direction to the corresponding movement in the preceding experiment. There it was along the length of the lines; here it is at right angles to the lines. In four cases the fields were reversed—*i. e.*, the red field was placed before the left eye, and the green before the right eye. These cases are numbered in the table 4, 5, 9 and 10.

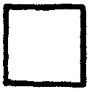
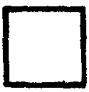
TABLE VI.

Experiments.	Red, per cent. of time seen.	Green, per cent. of time seen.	No. of changes for each field.	
	COUNTED LINES ON RED FIELD.			
1	68	32	21	
2	67	33	18	
3	69	31	16	
4	75	25	10	} Reversed fields.
5	73	27	16	
	COUNTED LINES ON GREEN FIELD.			
6	35	65	17	
7	40	60	15	
8	45	55	17	
9	31	69	23	} Reversed fields.
10	37	63	20	

The number of changes in the normal records preceding each of the above was 22 per 100 seconds.

Sec. 3. *Figures*.—In Section 2 all the eye movements were made by conscious effort. In Section 3 no conscious eye movements were made, but such variations of the lines upon the colored squares were employed as would induce more eye movement in one case than in another. In some cases there were no lines at all upon one of the fields. In the first three series the red field was without lines, while the green field retained them. The result might be expected that the red field would induce very few movements, while the green field would have the opposite effect. In the next three series lines were

TABLE VII.

Experiments.	Red, per cent. of time seen.	Green, per cent. of time seen.	No. of changes for each field.
	 RED.	 GREEN.	
1	30	70	19
2	32	68	27
3	27	73	18
4	28	72	23
	 RED.	 GREEN.	
5	21	79	21
6	36	64	20
7	27	73	21
8	30	70	21
	 RED.	 GREEN.	
9	34	66	19
10	23	77	22
11	24	76	20
	 RED.	 GREEN.	
12	43	57	25
13	42	58	25
14	45	55	33
15	50	50	27
	 RED.	 GREEN.	
16	57	43	22
17	59	41	29
18	52	48	21
19	52	48	24
	 RED.	 GREEN.	
20	39	61	26
21	40	60	31
22	53	47	25
23	49	51	27

In experiments marked 3, 4, 7, 8, 10, 11, 14, 15, 18, 19, 22 and 23, the fields were reversed.

placed upon both fields. This might be expected to equalize the eye movements.

Inspection of Table VII. will show that those fields which would be expected to induce the greatest amount of eye movement remained longest in consciousness; but in cases where both fields contained lines the rivalry tended to approach a normal condition.

Sec. 4. *Moving Field.*—What would be the result if the movement were transferred to the external stimulus while the eyes were kept at rest as far as possible? Section 4 deals with the problem. The two fields were the same as those in Experiment 1—a red and a green field with diagonal lines; the red for the right, and the green for the left eye. The red field was kept in motion by means of the pendulum already described. The green field remained at rest. The areas of the two fields were restricted to one square centimeter each by a black cardboard in which had been cut square openings of that size. This card was placed in the stereoscope which stood before the swinging red field and the stationary green field in such a way as to give the required stimulus. Other than the moving field the conditions were the same as in the normal records.

TABLE VIII.

	RED FIELD MOVING.		
Experiments.	Red, per cent. of time seen without the green.	Green, per cent. of time seen.	No. of changes for each field.
1	59	41	25
2	53	47	24
3	60	40	21
4	57	43	17[1]
5	53	47	15[1]

[1] The number of changes in the normal records for this day was only 16 per 100 seconds. The day was cloudy and consequently quite dark. The influence which intensity of light has upon the changes will be discussed in a later section.

In all the preceding experiments the displacement of one field by the other had been complete, but in this experiment the results were exceptional. The moving lines of the red field were seen practically all the time. The stationary green field came and went with its usual regularity. The length of time it remained, however, was somewhat shorter than under normal conditions. While the green field was present the lines of the red field were still seen moving back and forth, seemingly *through* the lines of the green field. This consciousness of the lines was not clear and distinct when the green field was present; at times it would reach the vanishing point. Then, when the green field disappeared, it would again return to its maximum degree of clearness. The figures in the second column express only the per cent. of time the red field was seen *alone*. The third column might be said to express the per cent. of time that the green field was seen *in spite* of the moving lines of the red field.

Sec. 5. *Muscle Contraction*.—The usual red and green fields with the black lines were used in this experiment. The new condition introduced was that of muscle contraction: First, contraction of the muscles of the arm and leg of the right side of the body. Second, contraction of the arm and leg of the left side of the body. This contraction was flexion of the arm and leg. The position was held rigidly during the experiment. As much strength as the subject could command was expended in the contraction. In the first series the muscles of the right side of the body were contracted, while the muscles of the other side were relaxed as far as possible. In the second series the opposite condition existed. As is the case in every experiment reported, a normal record was taken as a preliminary to every series. Table IX. contains the results from six subjects.

TABLE IX.

Subjects.	NORMAL.			MUSCULAR EFFORT, RIGHT SIDE.			MUSCULAR EFFORT, LEFT SIDE.		
	Per cent. of time seen.		No. of changes for each field.	Per cent. of time seen.		No. of changes for each field.	Per cent. of time seen.		No. of changes for each field.
	Red.	Green.		Red.	Green.		Red.	Green.	
1	50	50	41	66	34	35	50	50	40
2	51	49	67	46	54	55	48	52	53
3	52	48	14	46	54	18	49	51	19
4	55	45	25	60	40	22	52	48	23
5	51	49	15	47	53	20	49	51	27
6	57	43	25	59	41	21	57	43	24

Red field—right eye. Green field—left eye.

Table X. gives the averages of ten normal records and the variations of the six different subjects. All figures are in per cents.

TABLE X.

Subjects.	AVERAGE FOR TEN NORMALS.				
	Red.	Green.	Av. V. for red.	Av. V. for green.	Max. V.
1	59	41	4.3	4.2	10.
2	50	50	1.5	1.	4.
3	49	51	2.8	1.8	4.
4	58	42	5.	8.	10.
5	53	47	1.8	2.1	4.
6	59	41	3.	3.3	7.

A comparison of the figures in these tables gives no data for any definite conclusions. In some there is indication of disturbance of the normal rivalry, but there is no uniformity in its effect. In order to check these results the experiment was repeated upon myself with great care. The results are given in Table XI.

TABLE XI.

Experiments.	NORMAL.			MUSCULAR EFFORT, RIGHT SIDE.			MUSCULAR EFFORT, LEFT SIDE.		
	Per cent. of time seen.		No. of ch'ng's for each field.	Per cent. of time seen.		No. of changes for each field.	Per cent. of time seen.		No. of changes for each field.
	Red.	Green.		Red.	Green.		Red.	Green.	
1	48	52	24	52	48	21	59	41	20
2	52	48	26	57	43	17	59	41	19
3				56	44	15	62	38	19
4				59	41	15	58	42	17
5[1]	55	45	27	55	45	23	53	47	17

Red field—right eye. Green field—left eye.

The effect seems to be the same whether the muscles of the right side or of the left side are contracted—*i. e.*, an increased length of time for the red field. The number of changes was decreased during muscular activity.

[1] In this case the fields were reversed.

[2] Averages of normals and their variations are to be found in Table IV., Sec. 1.

If instead of the total time, we consider the length of each individual change or phase of the rivalry in the last experiment, we get the following averages:

	Av. length of time of each change.
Normal.[1]	
Red[2] field—50 changes,	2.0 seconds.
Green[3] field—50 changes,	2.0 seconds.
Right side contracted.	
Red field—68 changes,	3.1 seconds.
Green field—68 changes,	2.5 seconds.
Left side contracted.	
Red field—75 changes,	3.1 seconds.
Green field—75 changes,	2.1 seconds.
Average variation of normal records.	
Red field,	.46 second.
Green field,	.50 second.

Whatever may be the relation between the motor centers for the two halves of the body and the visual centers for the two retinæ, there was no corresponding change in the functioning of the latter to agree with the change in the activity of the muscular apparatus. Under both conditions of activity the result was the same. The field seen by the right eye, the red field, remained longer in consciousness without a corresponding decrease in the length of time the other field was seen. The rhythm of the rivalry was somewhat slower under these conditions.

Sec. 6. *Colored Borders.*—Borders of the same color as the red and green squares were placed about them in order to determine what effect they would have upon the rivalry. Borders of different widths were employed, and four series of experiments made: 1st. A red border around the red field, and no border except the black background for the green. 2d. A

[1] The average of 1,200 changes and their variations will be found in Table XIII.

[2] Right eye.

[3] Left eye.

green border around the red field, and no border for the green field. 3d. A red border around the green field, and no border for the red field. 4th. A green border for the green field, and no border for the red field. In each case one of the eyes received only the impression from the usual stimulus, while the other eye received the added stimulus of the colored border, in the first case of the same color, in the next of the opposite color. Five subjects took part in the experiments, and altogether about two thousand changes were recorded. The results show that these borders had very little, if any, effect upon the rivalry of the original fields. The colored borders and the black background of the opposite field showed a rivalry independent of the rivalry of the squares, which fact suggests an interesting question for investigation: Under the same external conditions, in what respects does the rivalry of the peripheral areas of the retinæ differ from that of the central areas?

Sec. 7. *Fields of Different Areas.*—The size of the green field in this experiment was reduced to one-fourth of the size of the red field, the latter being the same as in former experiments —one centimeter square.

These fields were so arranged upon a black card that when they were united in the stereoscope the green field fell upon the central portion of the red field. The following table gives the results:

TABLE XII.

Experiments.	Red, per cent. of time seen.	Green, per cent. of time seen.	No. of changes for each field.
1	36	64	19
2	34	66	25
3	31	69	26
4	32	68	19

Besides the rivalry recorded in Table XII. between the green field and the central part of the red field, there was also a rivalry between the outer part of the red field and the black surface of the card around the green field. Most of the time when the green appeared it displaced only its own area of the red field; so that it was seen surrounded by the outer portions of the red field. Part of the time, however, the whole red field disappeared when the green appeared—*i. e.*, the green field was seen surrounded by its own background.

This background was the black cardboard upon which the fields were placed. So there was a rivalry between the retinal elements, stimulated with a plain black surface in one eye, and the corresponding elements, stimulated with the striped red surface in the other eye. The rhythm of this rivalry was much slower than that between the red and the green surfaces. The black surface was in consciousness less than one-tenth of the whole time.

When the green field was seen in the middle of the red field the adjacent areas of the retina of the right eye were in directly opposed relationship to the perceiving center or centers, for the stimulus coming from one part of the retina was effective, while the stimulus coming from its adjacent part was not. Part of the stimuli coming from the right retina were inhibited by the stimuli coming from the corresponding points of the other retina.

But the stimuli striking both the effective and non-effective portions of the retina were the same. So if the rivalry depends upon the physiological condition of the retina we should expect that those portions subjected to the same conditions would function in the same manner. The fact that they do not, together with the fact that the retinæ have no connecting fibers, seems to me to be strong evidence in favor of a central explanation of the phenomenon of binocular rivalry.

Sec. 8. *Rivalry Under Normal Conditions.*—Before considering the next experiments it will be necessary to look more closely to what takes place in binocular rivalry under normal conditions. Within what limits do the single phases of the rivalry vary? Does fatigue or practice affect the rivalry? The following figures will throw some light upon these and other questions. These figures are from twelve normal records taken at different times during the year, and are in each case records of one hundred consecutive changes. The red and green fields with black diagonal lines upon them were the stimuli used in all normal records.

TABLE XIII.

RED—RIGHT EYE.			GREEN—LEFT EYE.		
Changes.	Av. length of changes.	Av. V.	Changes.	Av. length of changes.	Av. V.
1	1.93	.45	2	2.24	.75
3	1.96	.55	4	1.82	.53
5	1.80	.40	6	1.96	.55
7	2.24	.90	8	1.80	.37
9	2.15	.76	10	1.93	.55
11	1.92	.60	12	2.10	.76
13	2.18	1.00	14	1.93	.63
15	1.65	.40	16	2.06	.35
17	2.16	.70	18	1.70	.38
19	1.71	.80	20	1.82	.49
21	1.94	.50	22	2.03	.49
23	2.23	1.00	24	2.28	1.00
25	1.76	.55	26	2.20	.63
27	1.55	.40	28	1.81	.50
29	1.80	.40	30	2.24	.63
31	1.66	.43	32	2.10	.64
33	1.90	.35	34	2.05	.55
35	1.60	.40	36	1.90	.56
37	2.00	.50	38	2.03	.48
39	1.66	.50	40	1.82	.39
41	1.54	.60	42	1.72	.35
43	1.35	.25	44	1.54	.35
45	1.61	.42	46	1.73	.44
47	1.74	.33	48	1.87	.62
49	1.77	.58	50	1.85	.51
51	1.78	.48	52	1.68	.34
53	1.73	.42	54	1.70	.38
55	1.95	.62	56	1.76	.30
57	1.94	.41	58	1.80	.61
59	1.90	.53	60	1.85	.51
61	1.84	.56	62	2.05	.74
63	2.00	.47	64	1.84	.60
65	1.81	.41	66	2.13	.90
67	1.72	.50	68	1.90	.47
69	1.75	.50	70	1.75	.57
71	1.33	.36	72	1.43	.65
73	1.85	.44	74	1.80	.36
75	1.63	.31	76	1.93	.54
77	1.65	.33	78	1.65	.42
79	1.95	.21	80	1.80	.43
81	1.73	.40	82	1.66	.36
83	2.10	.63	84	1.90	.23
85	2.40	.65	86	1.80	.48
87	2.45	.40	88	2.36	.60
89	2.23	.63	90	2.30	.76
91	2.20	.67	92	2.08	.41
93	1.46	.44	94	1.75	.48
95	2.63	.65	96	1.85	.37
97	1.61	.45	98	2.13	.80
99	1.80	.60	100	2.00	.78
Average.	1.88			1.90	

The average number of changes per one hundred seconds for each field was 26 +.

No fatigue nor practice effect is shown by the records.

Sec. 9. *Light Intensities.*—In all the previous experiments the visual stimuli were brought to the retinæ by means of reflected light. In this experiment transmitted light was used. Square openings one centimeter in size were cut in the card for the stereoscope. These openings were covered with red and green gelatin films across which strips of black paper were pasted, making two fields like the ones of the former experiments. Instead of sunlight, electric lights were employed. The object of the experiment was to determine what effect changes of intensity of the light stimulus would have upon the rivalry. Five different intensities of light were tried. The experiment was performed in a darkened room. In order to diffuse the light properly one thickness of ground glass was placed between the films and the light.

Table XIV. gives the per cents. of time each field remained in consciousness for the different light intensities. Since the intensities of both fields were the same in all cases, we should not expect this to differ from the normal. Table XV. gives the average length of each change, or phase, under the different intensities.

TABLE XIV.

	Red, per cent. of time seen.	Green, per cent. of time seen.
Arc light, 1,000 c. p., at 50 cm. distance,	49	51
Incandescent, 80 c. p., at 50 cm., . .	46	54
Incandescent, 16 c. p., at 50 cm., . .	47	53
Incandescent, 16 c. p., at 400 cm., . .	48	52
16 c. p., hooded, very dim, ...	48	52

Table XIV. shows that as regards the ratio of the lengths of time which the red and green fields remained in consciousness the rivalry was normal.

TABLE XV.

	ARC.		INCANDESCENT.							
	1000 c. p. at 50 cm.		80 c. p. at 50 cm.		16 c. p. at 50 cm.		16 c. p. at 400 cm.		Very dim.	
	Length.	Av. V.	Length.	Av. V.	Length.	Av. V.	Length.	Av. V.	Length.	Av. V.
Red.	1.18	.23	1.37	.37	1.61	.49	2.08	.70	4.08	.73
Green.	1.21	.16	1.59	.21	1.78	.28	2.21	.50	4.39	.74
No. ch. 100 sec.	41		34		28.5		23.3		11.6	

From Table XV. we get the following points: The rate of fluctuation varies with the intensity of the light. (For the lowest intensity the light was not decreased beyond the point where the fields could be seen distinctly without straining the eyes, although it was intended to decrease it until this point was approached. For the highest intensity the light was as bright as possible without producing a dazzling effect.) With the lowest intensity the number of changes during one hundred seconds fill to about 12, while with the highest intensity it increased to 41. The length of the changes was correspondingly long for the lowest intensity, and short for the highest intensity, ranging from 4.39 for the lowest, down to 1.18 for the highest. From this we see that the length of the phases of the rivalry increased nearly four times, while the ratio of the red and green phases to each other remained normal.

If instead of lighting both fields equally, they are unequally lighted, then this ratio is changed. The following experiment shows this. The ordinary red and green squares illuminated by reflected light were employed. Two series of tests were made: First, the red field darkened. Second, the green field darkened. In both cases the darkened field received about one-fourth as much light as the brightened field. Table XVI. contains the results.

TABLE XVI.

	Red, per cent. of time seen.	Green, per cent. of time seen.	No. of changes for each field.
Red darkened, . .	39.	61.	22.
Green " . .	60.	40.	29.

The average length of each phase under these conditions is as follows:

TABLE XVII.

	RED.		GREEN.	
	Av. length.	Av. v.	Av. length.	Av. v.
Red darkened, . .	1.9	.45	3.00	.8
Green " . .	2.1	.80	1.36	.3

These figures show that when the two fields were unequally lighted the lighter field remained longer in consciousness. There is then an element to be considered here which did not show itself in the last experiment where the fields were equally lighted. There, a rise in the intensity of light caused an increase in the rate of the changes and a decrease in the time the field remained. Here, a higher intensity of light upon one of the fields caused an increase in the time it remained in consciousness, in spite of the fact that a high intensity of light might be expected to fatigue the activity of the retina more quickly. While both fields were equally lighted the shortened phases of the rivalry might find an explanation in the physiological fact that a strong stimulus causes the processes of assimilation and dissimilation of the nerve substance to go on more rapidly, and consequently the phases of the rivalry would take place more quickly. But such an explanation does not account for the fact that when the two fields were unequally lighted the brighter remained longer in consciousness. The psychical fact that a strong stimulus has a greater attraction for consciousness than a weak one enters into this phenomenon. In other words, the assimilative and dissimilative processes of the retina do not furnish an explanation for binocular rivalry.

Sec. 10. *Rivalry of After-images.*—Stimulation of the retinæ with the transmitted light of the red and green gelatin films used in the first part of Experiment 8 gave very persistent and distinct after-images. Now, since the after-image in the one eye was sufficiently different from the after-image in the other eye not to fuse with it, and since they both had the same local sign, they were not seen at the same time. The result was that here, too, the phenomenon of binocular rivalry appeared. The changes of the images were complete and distinct. The records of this rivalry given below consider only the rivalry of the diagonal lines of the fields. The changes of the colors were not recorded. The length of direct stimulation in each case was one hundred seconds; the light was then turned off, the eyes lightly closed and the changes of the after-images recorded. Seven different tests were made. Table XVIII. gives the ratio of the total lengths of time the two after-images remained in consciousness for the seven tests. Table XIX. gives the average length of the individual phases.

TABLE XVIII.

Experiments.	Red, per cent. of time seen.	Green, per cent. of time seen.
1	50	50
2	49	51
3	51	49
4	56	44
5	52	48
6	50	50
7	49	50

TABLE XIX.

Experiments.	RED.		GREEN.	
	Average length of each change.	No. of changes.	Average length of each change.	No. of changes.
1	5.08	10	5.14	10
2	4.94	10	5.08	10
3	4.88	10	4.58	10
4	7.88	7	6.21	7
5	7.70	7	7.20	7
6	6.60	7	6.55	7
7	7.00	7	7.43	7
Ave.	6.30		6.02	

Each one of the seven tests was continued for one hundred seconds, or the time nearest one hundred seconds in which there was an equal number of changes for each image. The variation of the phases of the rivalry during a single sitting averages about 1.

There was a large difference in the lengths of the phases in the different sittings taken on different days, which can be seen from the table.

The rate of fluctuation in the rivalry of after-images is much slower than in the case of direct stimulation. The stimulus from which the after-images resulted was the brightest intensity used in the experiment of Section 9, an arc light of one thousand candle power at a distance of fifty centimeters from the gelatin films. Under the direct stimulus the individual phases were only 1.1 and 1.2 seconds, while in the rivalry of the after-images they averaged 6.3 and 6.0. The number of changes per one hundred seconds for the stimulus was 41, while the after-images averaged but 8+.

The ratio of the time which the two images were seen is practically the same as in the normal records.

Sec. 11. *Fields of Same Color.*—In order to determine whether the possible different adaptation of the lens for red and green lights had any effect upon the rivalry of the red and green fields employed in the preceding experiments, two series of experiments were made in which the fields for both eyes were of the same color; first, red; second, green. Otherwise the character of the fields was the same as in the normal experiments with reflected light. The same number of black lines was employed and the same sized squares. The only difference between the two fields was that of the direction of the lines which made two sets of lines at right angles to each other in the combined field. The first Table (XX.) gives the ratio of the two fields, and the second (XXI.) the average lengths of the individual changes.

TABLE XX.

Experiments.	Right field, per cent. of time seen.	Left field, per cent. of time seen.	No. of changes for each field.
	BOTH FIELDS RED.		
1	45	55	31
2	46	54	31
	BOTH FIELDS GREEN.		
3	46	54	29
4	45	55	28

TABLE XXI.

Experiments.	Right field, av. length of each change.	Left field, av. length of each change.
	BOTH FIELDS RED.	
1	1.40	1.77
2	1.44	1.70
	BOTH FIELDS GREEN.	
3	1.56	1.83
4	1.60	1.92

These tables show that the rivalry under the above conditions was normal.

Sec. 12. *Monocular Rivalry.*—In all the preceding experiments we have been considering rivalry as manifested between corresponding areas of the two retinæ. Is it possible to get a rivalry of diverse stimuli when they fall upon the same area of the retina of one eye? Will two different objects, when so arranged that their light rays fall upon the same point of a single retina, be seen as one or two? If, under these conditions, the objects have the same local sign, we should expect the stimuli to fuse. This is what takes place when red and green sectors are revolved upon a color wheel. The green and the red are brought upon the same point of the retina at practically the same time, and the different stimuli are fused and perceived as a gray. There is, in this case, no fluctuation of the red and green stimuli in consciousness—in fact they are not in consciousness at all. A constant and even gray presents itself. This fusion is what we should expect in every case where different stimuli are brought by any means upon the same point of the retina. By means of a prism I was able to superpose upon the same point of one retina the two red and green squares that have been used in the experiments in binocular rivalry. If the thin edge of a prism is brought as near as possible to the eye so that this edge is in line with the perpendicular plane which cuts the eye into right and left halves, then one-half of the field of vision is seen through the prism and the other half is seen directly; but the half seen through the prism is bent in the direction of the other half, so that a part of the one half is superposed upon the other. Diverse stimuli are thus brought together upon the same point of the retina. Under these conditions the red and the green fields could very easily be placed so that they appeared to come from the same position in space. For convenience the prism[1] which I used was set in one side of a stereoscope frame, and the frame mounted upon a solid standard. This formed a rest, which is necessary in order to eliminate movements of the head.

The red and the green fields were placed in position on one side of the stereoscope so that one was seen directly, while the other was seen through the prism, and yet both seemed to come from the same place—*i. e.*, both fields fell upon the same retinal point.

Instead of complete fusion of the red and the green backgrounds, and a fixed appearance of the crossed lines, there was only a slight fusion of the colored backgrounds and no fixity of the lines. Both the red and the green backgrounds were seen at the same time—the red lying just a little behind the green, and appearing through it, as it were. The red field was most intense at the extreme left edge,[2] and gradually became less intense toward the right. The green field was most intense at the right edge, and decreased toward the left. At the center of the square, however, the two fields appeared with about the same intensities.

Now the interesting part of the experiment is that if the center of the field was fixated, a rivalry of the colors was perceptible. Neither disappeared entirely: but at times the red would appear very distinctly while the green would fade; then the red would fade and the green appear distinctly. The two sets of lines showed the same fluctuation, keeping pace with the changing of the intensities of the colors. Sometimes one of them would disappear altogether.

This rivalry of the colors and of the lines was much slower than the rivalry in binocular vision. A very slight movement of the eye to the right or to the left would cause changes in the intensities of the fields; so that extreme care was necessary in order to avoid the movements, or, at least, not to confuse

[1] 20° prism.

[2] The red field was placed on the left-hand side.

changes caused by them with the rivalry of the fields, which is independent of eye movements.

If one of the fields is so placed that its reflection appears on the surface of a plate of glass at the same point through which the other field is seen directly, then both fields are superposed for the two eyes at the same time. The apparatus for Ragona Seinà's experiment of mirror contrasts serves as a convenient means for superimposing the fields.

Summary.

The length of time which the fields normally remain in consciousness was increased by direct will power.

Efforts to decrease the number of changes of the fields in a given time were unsuccessful.

With the so-called pure will efforts there were in every case accompanying eye movements.

Elimination of the eye movements decreased the ability to hold either of the fields.

The introduction of conscious eye movements was accompanied by a lengthening of the time of the field whose lines served as the guide for the movement.

Counting the lines upon either field increased the length of time that field remained in consciousness.

Figures which induced the greatest eye movement remained longest in consciousness.

The lines of a moving field remained in consciousness nearly all the time, but did not inhibit the normal rivalry of the two fields.

Contraction of the right side or of the left side of the body had the same effect upon the rivalry, viz., increased the time which the field before the right eye was seen.

Colored borders did not affect the rivalry.

Of two fields of different sizes, the smaller remained longer in consciousness.

Under different conditions adjacent parts of the retinæ showed different rates of rivalry at the same time.

Increase in the intensity of the light stimulus caused an in-

crease in the rate of the changes, while the ratio of the phases of the rivalry was normal and constant.

Of two unequally lighted fields, the lighter remained longer in consciousness.

After-images showed the same phenomenon of rivalry; but the changes occurred at a slower rate than in the case of direct stimulation.

When both fields were of the same color the rivalry of the two sets of lines was not affected.

Different stimuli falling upon the same area of the retina of one eye produced the phenomenon of rivalry.

There seem to be some facts in the foregoing experiments that point toward an explanation of binocular rivalry as a purely physiological process. There are others which point to its explanation as a psychical process. The effect which different intensities of light had upon the rate of fluctuation might be interpreted as a purely physiological effect depending upon the anabolic and catabolic processes in the tissue of the retinæ. On the other hand, the fact that, of two fields of different intensities, the brighter remained longer in consciousness, seems to point to the attention process as the effective factor. The effect which eye movements had upon the rivalry of the fields may also be looked upon as physiological. These movements brought into activity new parts of the retinæ, thereby relieving the parts which had been active in reporting the stimulus to the higher centers. This division of labor enabled the retina to maintain its activity for a longer length of time. Now supposing that these movements, as was the case, were made only when one of the fields was in consciousness, and that when the other field appeared the movements ceased: in the latter case there would be no change of retinal elements; therefore the activity of the retina reporting this field would run down much more quickly. Thus an explanation would be offered for the longer length of time which the other field remained in consciousness. But in all cases of eye movements the fact must be considered that *not one, but both* eyes moved at the same time. Take, for instance, the experiment where eye movements were introduced when the red (right) field was seen. Now, movements along the lines of this field with the right eye were accompanied by movements across the lines of the green or unpresented field by the left eye. So there was a change of retinal elements in this eye as well. When, in the course of the rivalry, the green field appeared and eye movements ceased, then the fixity of the retinal elements was the same for the right eye as for the left. So far as a change of the retinal areas is concerned, the conditions were the same for both eyes. There was a point of difference, however, in regard to fixation. When the red field was in consciousness there was fixation of the lines of that field by the right eye, which was necessary in order to follow the lines. This element of fixation was not possible in the same way for the left eye—*i. e.*, there could have been no adjustment to a particular line as was the case in the right eye. There was, in the one case, a particular and definite motor innervation coming from the cortical centers, while in the other this was lacking. This element was present also to a more marked degree when the lines of one of the fields were counted. Our conclusion, therefore, is that an explanation is to be found, not in terms of the physiological functions of the periphery but in terms of the central processes. This does not mean that it will be in purely psychical terms, for it is evident that the physical movements of the eyes should be considered as an effective factor in the rivalry under the conditions of the experiments.

The introduction of simple figures which tend to induce eye movements strengthened the belief that bodily adjustments play an important part in the phenomenon. But since the effect of these movements is not accounted for in the sense organs of the periphery, it may lie in the relation of the movements to the cortical centers; in other words, in the *meaning value* of the movements for consciousness.

A *purely psychical* explanation cannot stand before the fact that purely mental states were not able to control or affect the rivalry. It continued in its usual rhythm even when the attention was fixed upon one of the fields. In the case of the moving field opposed by a stationary field, the strong attraction which a moving object has for the attention process did not check the rivalry. The other field came and went with about its usual rate. When, however, the so-called pure act of attention was aided by some appropriate motor adaptation, then the effect upon the rivalry was most marked.

In the case of two unequally lighted fields, the brighter calls for a greater number of eye adaptations in the form of more definite and distinct accommodations of the eye to points upon its surface than is the case with the darker field. The darker the field the more even does its surface appear—*i. e.*, the less the degree and the fewer the differences in the surface; it approaches a perfectly plain surface in low intensities of light. Consequently fewer points upon its surface call for fixation. A plain surface is not explored by the eye as thoroughly as a diversified surface is—nothing new is to be gained by such exploration, and so the mind is accustomed to fill in the content at once without the trouble of further eye adaptation. On the other hand, the brighter the field the more points of difference on its surface appear, and consequently the greater the number and more definite the eye adaptations. This was most evident where the red square seen by one eye was opposed to the plain black surface seen by the other eye. Here the black surface was in consciousness but a very small part of the time, the brighter field crowding it out. The same effect appears in the experiments of Section 3, where a plain red square was opposed to the figures of the green square.

In view of these considerations it seems that either a purely physical or a purely psychical explanation of binocular rivalry fails. The true explanation must be looked for in the nature of the psycho-physical processes of the cortical centers, the activity of which depends, not only upon the incoming nerve stimuli, but as well upon the outgoing motor discharges. The character of the discharge which determines into what motor reaction it is to end, is what is meant by the 'meaning value' of bodily movements or adaptations.

Consciousness, from the above point of view, depends for its existence and character upon the transference of sense stimuli into motor paths.[1] This hypothesis considers the in-

[1] Münsterburg, Physiological Basis of Mental Life; paper read before the American Psy. Ass., N. Y., Dec., 1898. *Science*, March 24, 1899.

coming, or sense stimulation, and the outgoing, or motor innervation, as a single nerve process. There is no point of separation between them. The motor discharge is necessary in order that any central activity take place. This point will be discussed in its more definite aspect later.

Binocular rivalry, then, would be at once 'psychical' and 'physiological' in that it is dependent upon central processes, and is affected by the nature of the motor adaptations. Fundamentally it may be considered as a rivalry of discharging centers whose activity is inseparably connected with incoming sense stimuli.

The important part which the motor adaptations of the eyes played in these experiments in binocular rivalry forms a connecting link between the consideration of the effect which their inhibitions had here and the effect of inhibited motor responses in other parts of the body. I shall add, therefore, the report of some experiments on the inhibition of the motor elements of language expression and its effect upon conscious states.

INHIBITION OF MOTOR REACTIONS.

As has been indicated, inhibition, in so far as it is a question for psychology, is most manifest in the psycho-physical processes. Ideas, feelings and emotions are intensified or inhibited according to the character and intensity of the bodily adjustments. On the other hand, mental states have an intensifying or inhibiting control over the bodily reactions and functions. Between the mental and the motor elements of the psycho-physical processes there are many cases of direct conflict and repression—*i. e.*, certain mental states have a direct inhibitory influence upon certain motor adjustments, and certain motor adjustments have a direct inhibitory influence upon certain mental states.

On the other hand, certain motor adjustments are very important for the mental states. Many conscious states show very plainly that they are accompanied at all times by particular motor adjustments. In many cases the major part of the content of the mental state is that furnished by the motor adjustment. If they are in any way inhibited, the mental state is inhibited.

An instance of motor adjustment accompanying conscious states is the almost universal tendency to express ideas in words at the moment they are presented to consciousness—*i. e.*, to think in words. Some people become hoarse listening to a long lecture. Observation in such cases reveals the fact that the listener is repeating to himself the words of the lecturer. Usually this tendency stops with the rudimentary stages of enunciation. The muscles of the vocal cords, throat and respiratory organs are slightly innervated and adjusted, but the process goes no further. Sometimes, however, the enunciation is complete so far as the adjustment of the muscles of the vocal cords, throat and mouth cavities is concerned. There is a tendency to make these adjustments not only when we hear spoken words, but to make them in response to other stimuli. We are likely to utter the name of any object upon which the attention rests. If an object is taken in the hand without knowing beforehand what it is, the vocal organs are ready with its name at the instant of recognition. If, for any reason, the motor apparatus does not respond properly, there is an interruption in the conscious stream. In moments of surprise, anger, joy or grief the motor expression of mental states is unrestrained. In ordinary mental states these adjustments are so rudimentary and delicate that only the closest observation will reveal them. A slight alteration in the rate, direction or pressure of the breath may in many cases be the only clue to them. That they are present to some degree during the greater part of conscious processes I am convinced.

In the psychological tests made upon the Freshmen of Columbia University there was one memory test which called for the reproduction of a given series of numbers, under two conditions: first, the numbers were read aloud to the subject; second, they were shown to him. In the last case the numbers were placed upon cards and shown one at a time. In both cases it was noticed that nearly every one tested repeated to himself the names of the numbers as they were read or shown. The question suggested itself as to what would be the effect upon the ability to remember the numbers if these motor responses were in any way inhibited. Accordingly a number of simple tests were made, the results of which follow.

Section I.

The object of the following experiments was to test the memory under two sets of conditions. First, under conditions which in no way inhibited the tendency to pronounce the names of the memory series when given. Second, under conditions which inhibited this tendency.

In the experiments of Section I the series used was made up of combinations of the nine digits. The simpler arithmetical relations were avoided in the make-up of the series. The number of digits in the series depended upon the ability of the subjects. It varied from seven to eleven. After reading the series to the subject he was required to repeat it in its exact order if possible. Misplaced and inverted digits were counted as errors: the first as one, the second as two errors. When school children were subjects they were asked to reproduce the series upon a slip of paper. The numbers were read at a uniform rate of one per second. There were forty-two subjects. Three were graduates in psychology, one a graduate student in another department of the University, fifteen students in the Horace Mann High School, and twenty-three pupils in the fifth grade of the same school. The two conditions of this experiment were as follows: First, the subject was asked to remember the series in the easiest or most natural way. Second, the subject held his breath while the series were read to him. It was thought that the holding of the breath would inhibit the tendency to repeat the names of the digits. Subjects W, D, R and G were examined individually; the school children were examined in groups. Under the first condition of the experiment *every* subject repeated to himself the numbers of the series as they were given; under the second, holding the breath, this tendency was somewhat suppressed. The following table gives the results:

TABLE XXII.

MEMORY SERIES (DIGITS) AUDITORY.

	REPEATED NAMES.		HELD BREATH.	
Subject.	1 No. Given.	2 No. Remembered.	3 No. Given.	4 No. Remembered.
W.	80	75	80	60
W.	100	78	100	56
W.	110	94	110	77
R.	80	59	80	49
D.	80	58	80	45
W.	90	90	90	44
G.	90	86	90	35
	630	540	630	366
5th Grade.	161	117	161	104
	161	117	161	107
	161	110	161	90
	161	113	161	90
	161	114	161	83
High School	120	98	120	77
	120	85	120	92
	120	80	120	72
	120	88	120	66
	1285	922	1285	781

The decrease in the number of digits remembered when the breath was held may be due not to the absence of the motor adjustments, but to a distraction of the attention caused by the attempt to hold the breath and recall a series, which was being read, at the same time. Even if we admit that the lessened ability to remember a particular series was due to distraction of the attention, there is this consideration: Many psychologists hold that the attention is largely a matter of motor adjustment anyway; so it is quite possible that the adjustments necessary for holding the breath, by inhibiting the motor adjustments for the memory series, made it impossible for the attention to remain undivided at its task. This, of course, still makes the inhibition of the motor elements the effective factor in the inhibition of the conscious states. I am inclined to think, however, that if the effort to hold the breath came from the higher centers, it certainly would act as a distracting element in the attention process. But holding the breath for the short period of seven to eleven seconds requires very little mental effort. We often hold the breath for longer periods of time during mental activity without being aware of it.

In order to test the matter, another experiment was performed under the same conditions, with the exception that the enunciation of the names of the digits was required when the breath was held. It was found that it is possible to make the proper motor adjustments for enunciation when the breath is held, if one desires to do so. The element of adjustment which was not present in the last experiment during the series when the breath was held is voluntarily introduced by the subjects in this experiment.

This enunciation of the names required some effort, at least on the part of the subjects, so that there might be expected to be an added opportunity for distraction of the attention. Table XXIII. gives the results:

TABLE XXIII.

MEMORY SERIES (DIGITS) AUDITORY.

	REPEATED NAMES.		HELD BREATH BUT REPEATED NAMES.	
Subjects.	No. given.	No. remembered.	No. given.	No. remembered.
G.	80	64	80	64
5th Grade.	168	140	168	119
	168	118	168	121
	168	119	168	113
6th Grade.	133	118	133	98
	133	95	133	85
	133	84	133	88
	133	92	133	97
	1116	830	1116	785
M.	70	62	70	64
G.	70	69	70	69
H.	70	56	70	56
	210	187	210	189

The difference in results under the two conditions was very slight. This seems to indicate that the distraction of the attention as such in the first experiment was not sufficient to account for the decrease in the number of digits remembered. Holding the breath often takes place during moments of mental effort;

but in the case of the first experiment it took place under conditions which tended to inhibit the motor elements of the memory process, and to this fact I attribute the lessened ability to remember the series.

Section 2.

Perhaps the most satisfactory way of inhibiting the adjustments for enunciation on the part of the subjects is to call their attention to the tendency and ask them to refrain from making them. A little practice will enable most subjects to eliminate the greater part of such adjustments. This was the method employed in the following experiments. Another change was made in the character of the memory series. Instead of numbers, colors were used. Squares of colored paper (1½ inches) were pasted upon white cards of a size convenient to

Table XXIV.

MEMORY SERIES (COLORS) VISUAL.

	Repeated Names.		Inhibited.	
Subjects.	No. Given.	No. Remembered.	No. Given.	No. Remembered.
W.	70	61	70	21
W.	70	65	70	24
D.	70	63	70	37
D.	70	66	70	54
Dxt.	60	59	60	19
B.	70	67	70	24
R.	50	50	50	17
F.	60	57	60	24
	520	488	520	220
6th Grade	147	134	147	77
	147	109	147	91
	147	98	147	66
	147	128	147	97
	147	98	147	56
5th Grade	56	45	56	15
High School (3 Subjects.)	21	10	21	9
	21	17	21	11
	21	17	21	9
	21	15	21	11
	21	18	21	10
	21	11	21	4
5th Grade	126	85	126	63
	126	80	126	58
	1169	865	1169	566

handle. The colors were red, brown, blue, green, yellow, orange and white. The cards were shown to the subject one after the other at the rate of one per second. In most of the experiments seven colors were employed in each series. When, however, the subject was able to remember more a larger number was given. The ability of the subjects to remember a series of colors shown, under the two sets of conditions given at the beginning of Experiment 1, was the object of the following tests. Under the first condition the names of the colors in the series were formed in muscular terms as they were given. Under the second condition the subjects refrained from making the motor adjustments. They were asked to think the colors in purely visual terms, and to avoid the motor elements involved in enunciation.

This table shows a marked falling off in the ability to remember a series of colors when the names of the individual colors are not repeated. The errors were not bunched, but evenly distributed. The following tables give typical records taken directly from my note book. They represent a single sitting for subjects D, W and F. Seven colors were given in each series, and ten series given under each of the two conditions. The top row gives the number of colors in each series correctly reproduced under normal conditions. The lower row gives the number correctly reproduced when the motor elements were inhibited.

SUBJECT D.										
Normal,	7	6	7	6	5	7	7	7	7	6
Inhibited,	3	2	1	2	3	3	3	2	2	3
SUBJECT W.										
Normal,	7	7	7	6	5	5	7	5	5	7
Inhibited,	2	1	2	0	1	3	1	2	4	5
SUBJECT F										
Normal,	5	5	6	6	6	6	5	6	6	6
Inhibited,	3	0	2	1	2	3	1	6	4	2

Some of the subjects showed a marked tendency to substitute other motor responses to the stimuli when the vocal adaptations were inhibited. This tendency manifested itself in impulses to designate by finger or head movements spacial positions for the colors as fast as they were shown, which scheme was used as an aid to the memory. The last two records of subject W were reported by him as cases where the following spacial scheme was used quite successfully as an aid in reproducing the colors: The colors were ideally arranged in the order of the spectrum, with the grays beneath them, thus:

R. O. Y. G. B.
White.
Brown.
Black.

Now when a color was shown, it was put into this ideal scheme and its position indicated by slight movements. This subject's space sense was almost entirely motor.

SECTION 3.

This experiment is the same as in Section 2, except in the manner of presentation of the series. Instead of showing the colors, their names were read to the subject, so that he did not see them at all.

TABLE XXV.

MEMORY SERIES (NAMES OF COLORS) AUDITORY.

	REPEATED NAMES.		INHIBITED.	
Subjects.	No. Given.	No. remembered.	No. Given.	No. remembered.
6th Grade	112 112	64 65	112 112	61 43
	224	129	224	104
S.	60	56	60	47
S.	60	58	60	37
S.	70	57	70	42
M.	70	66	70	33
H.	70	65	70	30
	330	302	330	189

The decreased ability to remember the series seemed to be due to the inability to get a full consciousness of the stimuli when the adjustments of the vocal apparatus were inhibited. One subject said that to ask him to remember a series of colors without allowing him to repeat the names to himself as they were presented, was to ask of him an impossibility, since if the motor elements were eliminated there would be no tangible content for the memory. Another subject was unable to imagine the colors in the reproduction until he had repeated the names.

The explanation of these results will be found, I believe in the impoverishment of the conscious content by the elimination of the motor elements. It is not to be denied that the effort necessary to inhibit the tendency to repeat the names might have been a distracting factor in the attention process. But to say that the attention was distracted in the above experiments may mean only that the attention process follows the motor adjustments of the body, and that the so-called inhibition of the ideas is due to conflicts of these bodily adjustments, or that distraction of attention is the antagonism of opposing motor discharges. So that the innervation of the vocal muscles which kept them from reacting in their usual way may have been the real cause of the inhibition of the memory images.[1]

Suppose other muscles of the body had been innervated to a like degree. This would have required as much attention, and would have been equally distracting. Is it reasonable to suppose that contracting the biceps of the arms rigidly while a memory series is presented would affect the ability to reproduce the series to the extent shown in the above tables? Certainly not; and the reason is just this: flexion of the muscles of the arms in no way interferes with the natural reaction of the muscles involved in vocalization. In Experiment 1 it was shown that when holding the breath did not interfere with the motor adjustments for naming the series presented there was no inhibiting effect in the memory process. I do not believe it reasonable to suppose that more effort was expended in these later experiments in refraining from making the motor responses

[1] I refer to the innervation of the vocal muscles which kept them from repeating the names.

to the presented stimuli. Therefore, our conclusion is that the inhibition of the motor responses in the above experiments had an inhibiting effect upon consciousness, and to this was due the failure to reproduce the series.

These results agree with those obtained by Theodate L. Smith, reported in the *American Journal of Psychology*:[1] Mr. Smith investigated the effect which the complex of throat, tongue and lip movement involved in articulation has upon the memory of nonsense syllables. His method of inhibiting the movements of the muscles of the throat and other vocal organs was to require the subject to count aloud while the series was shown to him. He found that from 13 to 18 per cent. more errors were made when the movements for articulation of the syllables were inhibited in this way. The following interesting points came out in his results: Syllables hard to pronounce were most frequently forgotten. There was a marked tendency to interchange the letters *b* and *p*, *t* and *d* when they appeared as the initial letter of a syllable.[2] Regarding the increase of errors during the series in which the enunciation of the syllables was suppressed by counting, the question arose as to whether this was not caused by the distraction of the attention due to counting, and not to the suppression of the motor elements. It was decided that the inability to remember was due to the absence of the motor elements, for it was found that counting did not affect the memory of series whose motor adjustments were made by other parts of the body than those employed in counting. This particular series used by Mr. Smith was made up of the characters of the manual alphabet. His subjects did not know the alphabet—*i. e.*, they could not associate the different positions of the hand with the letters of which they were

[1] July, 1896.

[2] These points are significant: When a syllable difficult to pronounce appears in a series it is just the concise and definite motor elements which are lacking in the presentation to consciousness—*i. e.*, the motor adjustments are not definitely formed. Hence the inhibition of the mental states involved. The interchange of *t* and *d*, *b* and *p*, is doubtless due to the great similarity of the muscular adjustments in their pronunciation. Abstracting from these, there is as great a difference between the contents of consciousness awakened by these pairs of letters as between other consonants, and there would be no reason for confusing them.

signs. Not knowing the names, there was no tendency to repeat them; but there was a tendency to form the different characters with the hand when their pictures were shown. His subjects were given a series of these pictures one after the other and required to reproduce it as well as they could. In one series they were allowed to make the characters with the hand as the pictures were shown. In the next series they were not allowed to do this. From 11 to 22 per cent. more errors were made in the reproduction of the second series.

After this experiment had been continued for some time, counting was introduced into the first series to see to what extent it would act as a distracting factor. It was found that the ability to reproduce the series was not decreased. It is reasonable to conclude that the increase of errors made in the nonsense syllable series was due to counting, not as a distraction ot the attention, but rather to the fact that it suppressed the motor adjustment for the series.

All these results show the great importance which the motor elements of articulation have in the make-up of mental states. In many trains of thought the content is almost entirely composed of the muscular complexes involved in the language expression of the thoughts. The usual mental content accompanying such a word as 'bubble' is inhibited if one trys to think the word with the lips wide apart. On the other hand, vividness of a mental process is produced by an intensification of the motor elements accompanying the process. If, while engaged in some mental work, such as reading or adding a column of figures, one is distracted by stimuli foreign to the work, the attention may be held to the task by reading aloud—*i. e.*, an increase in the intensity of the appropriate motor adjustments increases the stability of mental processes. A general intensified motor activity accompanies any attempt to overcome mental distraction.

The inhibitory effect which the suppression of motor activity has upon consciousness is not limited to the vocal apparatus. It is general. The whole motor mechanism is involved in the psycho-physical processes. In general, *inhibition of the motor elements tends to inhibit consciousness.*

Emotional states manifest in a very marked degree accompanying bodily conditions which are necessary for their existence. If the muscles are relaxed, head bowed down and the shoulders stooped, one can readily imagine and really produce the feelings of sorrow. On the other hand, if the chin is elevated, the head raised, the shoulders thrown back, the lungs filled and the muscles contracted, feelings of sorrow are immediately inhibited. Each emotional state has its appropriate bodily adjustments. Suppression of these adjustments tends to inhibit the emotion. A change of the motor elements may change the nature of the emotion.[1] All primary emotions imply tendencies to movement. Why not extend this tendency to all mental states? The alert bodily adjustment, the quick flashing eye are everywhere signs of mental activity. The discerning teacher is familiar with this fact. She can quickly read the mental condition in the bodily attitudes of the children. Vigorous, active thought is not found in relaxed and inactive bodies. James says: "No impression, or idea of eye, ear or skin comes to us without occasioning a movement, even though the movement be no more than the accommodation of the sense organ; and all our trains of sensation and sensational imagery have their terms alternated and interpenetrated with motor processes."[2]

It is useless to multiply instances of bodily movements which accompany, excite or intensify mental activity. They are everywhere in evidence. It is doubtful if it is possible to think intently without figuring the ideas in terms of movement, or without the motor adaptations for the language expression.

In emphasizing the importance of the motor elements in emotional states the advocates of the kinæsthetic theory of the emotions consider an emotion as dependent for its character entirely upon the reverberation of the motor adjustments—*i. e.*, upon the complex of sensations coming from movements or adjustments of the body which are the direct reactions of stimuli. That these returning sensations have their particular values for consciousness there can be no doubt, but this is not the relation between consciousness and motor phenomena that I wish to

[1] Ribot, Psy. of the Emotions, tr., p. 265.
[2] *Psy.*, Vol. II., p. 481.

consider. These movements and adjustments from this point of view may be considered in the same way as other external stimuli. The question is, Why and under what conditions do stimuli reach consciousness at all? It is my belief that no stimulus, either external or internal, is presented to consciousness without a motor reaction as a basis of the presentation. In other words, the *condition of consciousness is the transference of the action of the stimulus into or toward motor activity.*

The value of the motor side of consciousness from this point of view is not the value of the sensations coming from acting muscles, but rather the more fundamental fact that incoming stimuli are transformed into outgoing channels. Necessary to this conception is the following hypothesis concerning the action of the brain centers in their relation to afferent and efferent nerve fibers. The condition for the presentation of any stimulus is the permeability of the motor paths from the cortical centers—*i. e.*, consciousness arises only when the cortical centers involved are ready to discharge toward the periphery. The character of the mental state is determined by the location of the discharging centers. Its existence depends upon the *condition* of the motor paths: if they are open, the physiological nervous process necessary for consciousness can take place; but if they are closed, it can not. This conception regards whatever activity or change takes place in the so-called sensory and motor nerves and their centers as a *single* and *unified* process. The analysis of this process into a sensory process and a motor process, and the implied supposition that consciousness may accompany one, or both, is opposed by the above point of view. The sensory and the motor processes are inseparable. Activity in one part of a nerve circuit means activity in every part of that circuit, or, perhaps a better way of expressing it, the cortical centers are active only in transferring stimuli, external or internal, into motor channels. If the stimuli find a blocked system of motor channels from any cortical center, there is no activity of that center, and consequently no consciousness corresponding to such action.

Such an hypothesis as the above will give a better working physiological basis for the explanation of the facts of conscious life. The close connection which motor activity has to consciousness is better understood if we consider every sensation or idea as the psychical element in the transference of afferent nerve stimulation into efferent channels.

From the point of view of evolution of the higher from the lower forms of conscious life, should we not expect motor activity and consciousness fundamentally connected? In the simplest forms of life having consciousness, feelings and movements are, as far as we know, coexistent and undifferentiated. A certain feeling means a certain bodily movement. Since only a few simple bodily movements are possible the feelings are correspondingly few and simple. With the limitation of motivity there is a consequent limitation of consciousness. On the other hand, as the possibilities of movements increase through the higher forms, there is a corresponding increase in the complexity and variability of consciousness. In the lower animals every feeling or idea has an immediate motor expression which gets executed to a greater or less degree. In man many of of these expressions fall short of complete execution. They are suppressed, and we are able to trace them, or find their existence only in rudimentary form—in mere tendencies to act. Civilization and culture tend to modify and refine the expression of the motor innervation accompanying thought. In the child the natural and direct expression of its thoughts are least repressed, spontaneity is greatest; gradually, however, as the simplicity of its mental life develops into more manifoldness and complexity there is a general leveling tendency manifested in the motor expression of ideas. At the same time there is an increase in the number, variability and accuracy of motor expressions. This increase is parallel to the development of consciousness. In terms of brain physiology this repression of outward and visible expressions may find its explanation in the increased number of associated centers, whose activity means the transference of stimuli into a larger number of motor channels, thus modifying or even suppressing each other's action. In the child, before associations are formed to any extent, a stimulus may affect a small cortical area or a single center only. Later, when the center has formed connections with a number of associated centers, the same stimulus may call up through these centers various motor innervations which are antagonistic, and so neutralize or modify each other. The more complex the mental state—*i. e.*, the greater the number—and the more diversified the locality of simultaneously excited centers, the less are the chances for a direct and simple act.

The various motor discharges accompanying a complex mental state may expend themselves in impulses to act in opposite ways. Out of this possibility arises the phenomenon of inhibition. The limitations of the motor adjustments become the limitations of thought. If ideas were free from this physiological condition, there would be no reason why the soul could not attend to a multitude of them at the same time. The old theory that the body is the limit of the soul has a new meaning in this conception. In the simple cell form it is impossible to contract and expand at the same time, and the feelings appropriate to these activities are, therefore, exclusive. The same principle we wish to apply to the more complex forms of consciousness. States of consciousness depending upon mutually exclusive motor adjustments are not possible at the same time. Or, simultaneous stimuli calling for opposite motor reactions are not presented at the same time. Thus, from this point of view inhibition in so far as it pertains to consciousness is a phenomenon arising out of the limitation of the motor apparatus.

APPLICATION TO EDUCATION.

Education, in so far as it pertains to school life, has proceeded almost entirely upon the principle of dualism of mind and body. It seems to have been the presupposition upon which our school methods are based that between the spiritual and the physical natures of the child there is such a difference of kind that their development must necessarily be independent of each other. Consequently it has happened that all, or nearly all, the energy of the school has been expended in instruction directed to the spiritual nature, upon the supposition that it can be reached directly and without regard to the physical nature which underlies it. At first the intellect alone was the object of school instruction; gradually, however, since the abandonment of the old faulty psychology, we have come to recognize the fact that the soul does not develop in sections, but that the will and the feelings enter into every act of intellect. This marked a great advance in educational theories.

But as yet there is very little intelligent understanding of the importance and real nature of the motor elements in conscious life. It is true, Franke, Froebel, Pestellozzi and others have at various times emphasized the motor elements; but beyond the misconceived and badly applied kindergarten system and the manual training courses appearing in a few favored localities their efforts have not reached.

Our methods of school instruction are still largely based upon the dualism of mind and body. This conception has led to the neglect of what to my mind is a fundamental element in education—motor training. We look after what we call the intellectual nature of the child, but the bodily activities we leave to the play of circumstances. In fact, the first thing we do in school is to suppress as far as we are able the natural and spontaneous reactions of the child; we stifle the activity that is the foundation upon which conscious life is built. We imprison the child for hours each day in his seat; meanwhile we try to teach him *to think* without giving him a chance *to react*. The only reasons that our schools are not in reality institutions for the suppression of mentality is that, in spite of our attempts to suppress, the child does react. He reacts in some way to every thought that is presented. In the first years of life these reactions are very prominent.

For some time psychologists have been working upon the hypothesis that every mental state has a definite and particular expression in the body, but this law of dynamogenesis need not necessarily presuppose the inseparable connection of consciousness and the motor discharge. One might very well hold that every mental state tends to express itself in the motor mechanism, and yet conceive the motor expression to be merely a result following the mental state. The relation is more fundamental, as was seen in the pages of the preceding section; and this fundamental and necessary relation I wish to add to the law of dynamogenesis, and to insist that this addition makes it of primary importance for education. It gives us a clearer conception of how to apply the principle of self-activity in educational procedure. It is the child's ability to react, to make bodily adjustments and purposive movements which gives him the sense of *self* as opposed to his environment. His ability *to act* upon things, *to do* something with them, discovers to him the power and dignity of selfhood. The sense of mastery over environment, together with its place in the formation of character and self-reliance, comes directly out of the ability to execute bodily movements. In short, it is at the point of intersection, where consciousness and motor activity cross each other, that we may look for *self-consciousness* and *self-activity*, for these two are *one*.

It is not my object to make a plea for the recognition of motor activity in education merely for the sake of physical training *qua* physical training, for this would be proceeding upon the principle of dualism just as much as the attempt to train the intellect alone. My point is that there is no such dualism. The child should not be regarded as having two natures. On the other hand, he should be regarded as a single being with but one nature. This nature is at once physical and spiritual. Its elements are conscious bodily acts, impulses, feelings, emotions, and thoughts, none of which are purely physical, and none of which are purely spiritual—*i. e.*, the simplest physical adjustment to central stimulation has in it psychical elements, and the most complex idea has in it motor elements. It is rather my object to call attention to the motor elements because of their fundamental importance in the development of a self-conscious and self-active being. Instead of allowing the bodily activities which express themselves in the motor apparatus to shift for themselves, I would have them as carefully trained, and in as systematic a manner as the so-called faculties of the mind. I would have as great efforts made to help the child systematize his acts as is now made to induce him to systematize his thoughts. I would hold it as important for the child's development that he *learn to do* as to *learn to think*. I would not have the school *inhibit*, but rather *direct* the motor activity of children. All methods of instruction looking to these ends should, however, be tempered with the conception of the unity of mind and body. Instruction should be placed upon a monistic basis.

Some of our most advanced thinkers in education to-day are asking that the primacy of the will and the fundamental character of the feelings be recognized in the application of methods of instruction. They wisely assert that every mental state has its particular feeling value, and that no idea, however abstract, is without this element. Now since the feelings are primarily and inseparably connected with and dependent upon physiological adjustments we can readily see wherein the value of bodily adjustments and motor activity lies for instruction. Why should not the school recognize this principle, and, instead of disregarding the value of motor activity, seize upon it as a means to reinforce and intensify instructions? The close connection which the positions of the body have to the feelings and emotional attitudes should be recognized and studied by the teacher. A lesson in history calculated to inculcate manliness and courage, by its recital of deeds of great men, goes wide of its mark, if given to pupils who, either from long confinement or for any other reason, are in a generally relaxed muscular condition.

From the point of view to which this work leads, the value of manual training for the development of the mind—*i. e.*, as a culture study—finds its basis in the very nature of consciousness. Here we find an explanation of the fact that the boy who gains the ability to perform bodily adjustments in a decided, accurate and rapid manner is better able to think accurately and clearly, and why a hesitating and inaffective bodily reaction is the accompaniment of a weakened or confused state of mind.