

Gates, Elmer. "Brain Building and Mind Building, with Special Reference to the Sense-Training of the Eye and Ear, and Teaching Mentally Defective Children." *National Educational Association, Journal of Proceedings and Addresses of the Thirty-seventh Annual Meeting* (Washington, D.C., July 7-12, 1898), pp. 1051-56.

BRAIN BUILDING AND MIND BUILDING

by Professor Elmer Gates
of the Elmer Gates Laboratory,
Chevy Chase, MD

[ABSTRACT]

Certain experiments in physiological psychology prove that the training of any one sense develops the sensitiveness of all of the other senses. The experiments of Urbanschitz proved that certain sounds can be more distinctly heard when the auditor is at the same time looking at certain colors, and vice versa. He showed that certain colors could be seen at a greater distance when the spectator was simultaneously hearing certain sounds. The power to exercise voluntary attention is a product of civilization and training. Savage races have only spontaneous attention, and they are easily distracted. One of the results of modern education is the production in the pupil of the power to will his attention to a specific theme or object. I think this point has philosophic significance, namely, that the training of any one sense is able to develop not merely that special sense, but the general power of the whole mind. The application of this series of facts to the training of the mentally deficient, and to the training of the deaf and blind, is very obvious. If the eyesight is very weak and defective, there is sometimes more to be gained by first training some other sense than the eyesight, and most especially by training all of the other senses. I am particularly desirous fully to emphasize this point. I have an electrically propelled tuning-fork which for a period of a half hour gives a continuous amplitude of sound, and by carefully regulating the current by means of a voltmeter and ammeter a great sensitiveness and practically uniform loudness can be obtained. With this instrument I made several series of tests. When I began, the remotest distance at which I could hear this particular fork was 206 feet. I did this during the stillness of the night, and at a time when no other sounds of that character were audible. I followed this with three hours of daily training of touch, temperature, hearing, and taste for five days. At the end of that time I could hear the fork when at a distance of 286 feet. I repeated this

experiment upon two of my assistants, with similar results. I have a friend, sixty-eight years of age, who for five years had not been able to distinguish the difference between green and red. After careful tests I was fully satisfied that he could not tell the difference. Nine days' training of the temperature sense and of smell enabled him to distinguish the difference between the tints of red and green when the difference was only 8 per cent, and between all of the pitches of red and green when the luminosities were only ten. I think these experiments have a direct bearing upon the whole question of training the deaf and the mentally deficient.

THE SENSE STAGE OF MIND BUILDING

The next point which I wish to make is that in the training of any sense every typical discriminable sensation should be at least four times recognized by the pupil, so as to produce permanent structural changes in the brain, which changes constitute the memory enregistrements of that sensation experience. Many of you here will recall an account of my brain-building experiments upon dogs given in 1894 before the Geological and Anthropological Societies of Washington. These experiments have since then been in several ways corroborated. Thus Professor Aurelio Lui, in Stephano's laboratory in Italy, made experiments upon lower animals, from which he concluded that as animals more and more acquire facility in locomotion they get a correspondingly larger number of cells in the motor regions of the brain, and that these cells acquire more dendrites, filaments, and other structures. This is in corroboration of statements which I made a number of years before Lui's experiments. The general conclusion from these experiments was that every conscious mental experience causes, by its functional activity, in some definite part of the brain, a series of distinct structural and chemical changes, and that the refunctioning of these structures is essential to the remembrance of that experience.

At present I need not dwell upon the methods that prove that mental functioning produces brain structures. Huxley, long ago, called attention to the fact that function precedes structure. What I insist upon in addition to this statement is that the functioning which produces structure is always mental functioning. You are all acquainted with the general distribution of the areas of functional localization over the brain. Much clinical evidence, as well as direct psychologic proof, has been adduced in demonstration of this general truth. From my standpoint I would have you think of these areas as places where mind activities produce structural changes, and that these structural changes are

memory structures, which, if they were removed, would cause the loss of corresponding memories; that is, mind activity produces brain building, and not, as has been stated in the title, to my address in the published program, does brain building produce mind building. Let us take some one typical sense in order to illustrate what I mean by the statement that every typical sensation within the gamut of that sense should be several times recognized and discriminated by the pupil who is undergoing brain building by the mind-using process. I will select the hearing sense, because it is directly applicable to the subject under discussion. As you all know, the ear begins to recognize sound when the oscillating body moves about sixteen vibrations per second, and that at about 30,000 to 70,000 oscillations per second the upper limit of hearing is reached. Both the upper and lower thresholds vary with different people. An untrained ear will think eighteen oscillations per second to be a continuous sound, but after some training that person will be able to hear the separate beats of that tone, and then the lower limit of his hearing will have been raised. Some persons have their lower limit at twenty-seven oscillations per second, and others higher. Most people can hear beyond 30,000 oscillations per second, but there are a few who can hear up to 70,000, 75,000, and 80,000. Between this lower and upper limit we have from 30,000 to 75,000 and 80,000 possible pitches, the range depending upon the person. Of course, in the brain-building process the pupil must hear several times repeated each one of these pitches. Then, again, each pitch may have different degrees of amplitude or loudness, and the pupil should be made to hear different degrees of this loudness several times repeated. But there is still, from the standpoint of speech and deaf-muteism, a much more important quality of tone than pitch and amplitude, namely, that of tone quality. Helmholtz long ago demonstrated that the emotional characteristics of a tone were produced by the relative loudness of the harmonics or overtones present in the so-called fundamental tone. When you sound what you suppose to be a single note upon a musical instrument, there is present in that tone, in addition to the fundamental pitch, a certain number of higher pitches, called overtones. If the lower pitches of these overtones are present, the tone quality is sad; if the higher pitches of these overtones are present, the tone quality is cheerful; and so on thru the gamut of the emotions. Helmholtz showed by an experimental demonstration that the different vowel sounds could be produced by varying the harmonics of a certain fundamental note. The error in his method consisted in the fact that the tuning-forks which he used to represent simple pitches did not give simple pitches, but compound pitches. It is probable that no one here present has ever heard a fundamental pitch devoid of overtones. The first one I

heard was when, several years ago, I made the first experiment which led to the making of the electric sonometer. I succeeded in getting a tone of a single pitch. I accomplished it by placing between two electro-magnets, whose poles were separated a quarter of an inch, a thin metal disk, whose volume was such that its own pitch when struck was too high to fall within the limits of hearing. By interrupting, by means of a commutator, the current passing thru one of these magnets I was enabled to make this disk oscillate any given number of times per second, and the tone was entirely free from harmonics. By means of a series of fourteen of these disks electrically operated I was able to repeat Helmholtz' experiment with greater precision and much better results. Any one, two, or more of the overtones can by this device be sounded simultaneously with the fundamental tone, and all of the possible tone qualities can thus be produced, and any of the overtones can be given any desired degree of loudness. With this instrument it is possible to make all of the 80,000 pitches with every variation of amplitude and with all of the possible tone qualities of each pitch. To omit from the training of a child any group of pitches or tone qualities is to omit from the child's brain structural changes which might have been put there as memory structures, and it is to omit a certain amount of mind unfoldment in the child. If there are tone qualities which the child has not recognized and discriminated several times, then a certain anatomical, psychological, and logical completeness will be lacking. The way properly to train a child for brain-building purposes is this: first, the training should take place at precisely the same hour each day, so as to take advantage of the well-known phenomena of periodicity. After the third or fourth day a physiological habit will put the blood in the functional parts of the brain at about the time that the lesson is to take place, just as we get hungry at certain times at which we have habitually eaten. This vaso-motor dominancy occurs shortly before the time of the lesson, and thoroly supplies nutriment and recuperation to the cells that are soon to be used, and it provides the cells with the materials of growth and carries away the debris of previous activity. More brain growth can be produced in the fourth than in the three previous lessons because of the vaso-motor dominancy and because of the establishment of a functional habit in those parts of the brain. The next important point is that the child should have been completely rested, should have had sufficient sleep, and should have digested the previous meal. The lesson, of course, should take place in a manner cheerful to the child. Then it should be caused to hear, by means of the electric sonometer, all of the pitches of sound, giving only the fundamental tones, and varying the amplitude of each tone so as to go from the upper to the lower limit of loudness. And then the child should hear a glide from the

lowest to the highest note, including thus every possible pitch, and it should be done with different degrees of loudness. This will take some twenty minutes. It should be repeated every day at the same hour for at least five days in normal children, and perhaps for several weeks in the mentally deficient and in mutes. Then should commence the tone qualities. To the fundamental pitches from lowest to highest note should be added the first harmonic of different degrees of loudness. Thus, if you were to strike C of sixteen oscillations per second, you then add the first harmonic of thirty-two oscillations per second, and gradually increase it in loudness until the limit of musical amplitude has been reached. Then take the next higher musical interval, and so on thru the entire scale. About two octaves may be taken for the lesson, and repeated daily as long as may be needed, and then follow by the next higher two octaves, and so on until finished. Then the second octave can be added, and then the third, and so on until they have all been heard and discriminated. Then comes the training in the hearing of groups of harmonics, into which I need not now enter. In our present systems of music every note upon the piano has a different tone quality, and no two voices have the same tone qualities. It will be considerable of a novelty to you all to hear the notes of a tonic chord when the tone qualities are all the same, and a still greater surprise to hear the tonic chord in each one of the fourteen possible tone-quality changes and in each of the eight distinct group-harmonic changes. To develop any one part of the sense of hearing more than another part is to produce ataxia in the brain cells and in the mind. When a part is underdeveloped, its tendency is to become diseased; when a part is over-developed, its tendency is also to become diseased, thru congestion and other causes. Only an equable development can produce highest bodily health and highest mental soundness. In a normal child this training in the sense of hearing can be completed in four months, devoting to it twenty minutes per day.

Only when a function is developed as a whole can education normally and speedily take place. To omit any one logical or psychological part of the whole of a sense training is to introduce inexorable difficulties. I need not now dwell upon the methods for training the other senses. This method puts into the corresponding areas of the brain the memory structures which constitute mind embodiment for these mental faculties. I wish again to emphasize the statement that normal psychologic functioning cannot take place in the brain from which one important set of structures has been omitted; that such an omission causes continual difficulties in all subsequent stages of education; that under-development of any one part of the cortex produces disease and psychologic incompleteness.