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THE ORIGIN OF RIGHT-HANDEDNESS.

BY GEORGE M. GOULD, M.D.

DEPRIVED for a time of the use of his right hand, Carlyle was struck both by the vast importance and the mystery of right-handedness. He forthwith pronounced the question of its origin as one "not to be settled and not worth asking except as a kind of a riddle." He was more correct in saying that right-handedness is "the very oldest human institution that exists, indispensable to all human co-operation whatsoever; no human cosmos possible to be ever begun without it." Since the entry in Carlyle's diary was made hundreds have despaired or failed in the same manner to see any possible solution of the "riddle," and all the time, to an extent which Carlyle could never have dreamed, the extension of the influence of right-handedness has penetrated more profoundly and dominatingly into all the departments of practical, commercial, manufacturing and social life. There is no medical science or practice which can ignore it; the law must take constant cognizance of it; mechanics and tool-making are dominated by it; in every evolution or drill of ships or soldiers it is obeyed and kept in mind; and to railroads it dictates wrecks and millions of dollars of expense or savings. It makes or mars the calling, or failure, the success, happiness, or suffering of far more persons than is usually suspected, and scarcely one of us is unaffected in some way for good or ill by our dextral or sinistral complications, co-ordinations and inco-ordina-

tions. There are at least two million left-handed persons in our country, and they are either excluded or handicapped in almost every occupation they may adopt.

But Carlyle's insoluble "riddle" and the perplexities of hundreds of writers is now easily cleared up. The origin of right-handedness and left-handedness is plain, and equally so the history of the puzzle of "the Rule of the Road." Barbaric custom and war are the source of right-handedness; medicine, including cerebral anatomy and physiology, is able to explain the development of general right-handedness upon which rest all the mysteries of the Rule of the Road.

Beyond question the beginnings of right-handedness, and of general right-sidedness, date historically to primitive war and barter and the tally stick. The first differentiation of function in the use of the hands doubtless arose in telling off the left hand and arm to hold the shield which should protect the heart side of the body from the adversary's blows. This hand thus became known as the shield-hand. Except in a few very modern tasks the fact has dictated that the left hand has been generally the holding hand, chosen instinctively for the more passive or holding tasks, those requiring the less delicate or expert proficiency. Custom and language have long crystallized into an acceptance of the usage and even gone so far as to call the unlucky and misfortunate and awkward by the words *left*, *sinister*, *sinistral*, *gauche*, etc. Conversely, the right hand was chosen for the positive fighting task, and called the spear hand, and some of the most prized virtues, dexterity, dextrousness, etc., were named after the cultivated abilities of the right hand. The oldest Greek vases, and Homer, even the cave-men, demonstrate the existence of the distinctions of

shield hand, spear hand, and of right-handedness generally. In Xenophon's "Anabasis" the usages had become the routine of all military drill and discipline. In Smith's "Dictionary of Greek and Roman Antiquities" under the caption "Exercitus," may be found illustrations of the distinction emphasized. For instance:

"The facing to the right was always the usage, because if the evolution were performed in the face of an enemy, the shielded side could be presented toward him. . . . Similar maneuvers took place if the enemy appeared on the left, though, as this was the shielded side of the soldiers, and the danger was consequently less, it was frequently thought sufficient to keep the enemy in check by means of the cavalry and light troops. One point that a general had to be on his guard against was the tendency of an enemy, when advancing *ἐπὶ φάλλαγγος*, to sheer off towards the right, each man pressing closer to his right-hand neighbor in order to protect his unshielded side, so that the right wing frequently got beyond the left wing of the enemy."

The Roman army *exercitus* fixed the working of right-hand and left-hand orders down to the most minute details, and at West Point to-day the thousand peculiarities of military drill and custom and command are exemplifications of the consequences of shield hand and spear hand. Xenophon is still in command of every army in the world. Within the memory of living men companies of American militia often had, at the end, tail, or left of the battalion, a left-handed soldier, placed there in order that his musket, carried in his left instead of his right hand, might not clash with the right hand and its held gun of his next, right-handed, fellow.

In the word *digit*, and in the Roman numerals, and in the five strokes or cuts of the tally stick, we

have the most abundant and abiding testimony as to the origin of right-handedness and the location of the speech center, writing center, and counting center in the left half-brain. Counting, writing and speaking are single functions united into act by the volition, the seal and ratification of willing. By all savages for all time, in bargaining, the right hand has been held aloft, and one, two, three or four fingers shown and flung at the opposed bargainer. The gesture is always that of throwing the fingers or numbers at him. The whole hand is flung more energetically, when five is intended, *i. e.*, the letter V of the fork of the thumb and first digit. The scratches on the tally stick tell the same story and the diagonal thumb line, denoting *five*, run across four digits from upper left to lower right hand corner, indicates the thumb or fifth number. And so on, to *ten* or X, the crossed or doubled thumbs and to all other numbers. A close study of the Chinese and Japanese numerals convinces that the Roman system described, ancient as it is, is but a late offshoot of far older oriental usage, in general features the same the world over, and ages before history began.

The significance of these illustrations of primitive and persisting sign language, gesture language and counting language is that as they are executed by the right fingers and right hand, the motions of these fingers and this hand are instituted and innervated by "a center" or collection of brain cells in a certain spot (called Broca's convolution) placed in the left side of the brain. With one finger held up, or more, or the whole hand, with one or more cuts in the tally stick made, there was (and as the schoolboy's lip-motion in learning to read demonstrates) the spoken word, one, two, three, etc. Speech is almost the sole and

surely the chief muscular function that is single, not double, and which must be executed from a single initiating center of power and control. It is the fusion of all bilateralism, of all bodily and mental components and diversities into the unitized resolve which the whole body, mind and future, must obey. For the right-handed man this center of nervous origin and control is not in the right half-brain, nor in both half-brains, but only in the left. There also are the nervous or ganglionic mechanisms of memory, of writing, of the expert vision, of hearing, of leg-and-foot motion, which may be or are necessarily bound up with the right-hand deeds, the laryngeal and vocal acts issuing in language, or resolve, or social determination. The two halves of the brain are remarkably independent and separated from each other, as a thousand facts of physiology, disease and injury to brain-substance show. Therefore an injury to the speech or writing centers or to the centers of motion of the right-hand fingers of a right-handed person at once paralyzes or destroys, partly or wholly, the power of speech, of writing, of memory, the significance of words, etc. A similar injury to or disease of the corresponding parts of the right brain has no effect whatever upon these functions and acts. The child is born with no discoverable differences of cerebral structure or substance of the two cerebral hemispheres, and none ever appears thereafter. But about the sixth month of life the babe, which will naturally become a right-handed one, begins to put forth the right hand instead of the left to grasp an object, and the cerebral matter about the left third frontal convolution, however unchanged or like that on the right side, is thenceforth increasingly and exclusively used to control the organs of speech, of writing and of memory. Just here

comes into view the overlooked fact that the degree of right-handedness, of general dexterity and even of vocal and mnemonic function is different in different persons, and also that it is all a question of growth and progressive development. In the grunting savage or peasant the speech center, although located in the left brain, must be tremendously more simple than in a musician who knows by heart and sings and plays a thousand pieces of music, who speaks and writes a dozen languages, etc. The differentiation and complication of the cerebral mechanism whence spring all the acts begins in infancy with simple homogeneity, and grows in complexity with every year of added life. With each added year of differentiation the expertness grows, and it grows because the single cerebral mechanism has become more and more complex. Therefore with each added year the impossibility of educating the corresponding centers on the right-brain becomes greater. The ambidexterity sillies must therefore begin with infants if they are to succeed in making a dextral child of one naturally sinistral. Moreover, historically, the trend in all human beings is for them to become more and more exclusively and despotically either right-handed or left-handed, so that with each added generation the impossibility of ambidexterity will increase. Even now the attempt to reverse the law as existing in school children is both useless, expensive of life and in reality impossible. No attempt can wholly succeed; none should, and the partial successes produce cripples and awkward, if not disease and tragedy. The most foolish, impertinent, ignorant, expensive, resultless and maiming fad is that of the ambidexterity mongers. They do not know what they want, do not know that they cannot succeed, do not know that they

course the victim of any partial success. In infancy the left-handed child may be trained to be a right-handed one, but never to be an ambidextrous one. Why should a violinist bow equally well with both hands, and finger equally well with both hands? Why should he write equally expertly with each hand?

The fatuity becomes amazing with the recognition of the fact that right-handedness is necessarily bound up with right-eyedness, with right-earedness, with right-footedness. To train the child to be ambidextrous, eyes, ears and feet, — all must be trained to equal expertness in all tasks, and this is ludicrously impossible. We are as much right-eyed as we are right-handed, as any one can prove by looking at the image of the finger or a pencil held upright a foot before the eyes. Alternate opening and closing of each eye demonstrates (with some exceptions understood by oculists) that the right eye is unconsciously the one chosen to "fix" the image.

The reason for this general choice of the arm and hand, of eye, of ear and of leg and foot for conjoined expert tasks is easily recognized. It insures a speedier and more accurate synthesis of the cerebral functions which must be co-ordinated into a single act and result. The independence of the two halves of the brain makes it necessary that the bodily organs most commonly acting together and most interdependent should be incited and controlled by the cerebral centers in close contiguity and in one side of the brain. There is a measureable slowness of nerve-current transmission (between 100 and 200 feet per second), and even if the connecting links ("commissural fibers") between the two brain halves were much more intimate and numerous and short than they are, rapidity and accuracy of correlation and unifi-

cation in willed act would be impaired; and the safety and decision of the entire organism imperiled, if one or two of the coacting centers were in opposite hemispheres. That in the right-handed all these centers of origination and control are in the left, and in the left-handed in the right half-brain, is an inevitable consequence of the location of the speech center and writing center exclusively in one or the other. Writing and speaking are closely interdependent, both in origin (gesture, sign language, counting, Roman numeral or digit-throwing), and in all subsequent history and evolution. Their centers of origin and control must therefore be in close neighborhood and intimate union. Vision which preceded and accompanies all must therefore be in the same side of the brain. This, of course, holds as to hearing and, although less differentiated, to the associated leg and foot movements.

An astonishing and interesting consequence of all this almost draws itself. It becomes plain that, in the right-handed, intellectual life and progress are by means of the mechanisms of the left cerebral hemisphere. There is no intellect as we understand it except through speech, vocal and written, and the instruments of this function exist only in the left brain of the right-handed, and in the right brain of the left-handed. Mentality of the dextral therefore lives preponderatingly in and through the left half-brain. The fact strongly emphasizes and capitally illustrates the great biologic law that all progress consists in differentiation of function. In the evolution of civilization each bit of cortical brain substance is being told off to a certain peculiar office. That large parts are still without particular and discoverable duties argues plainly for the great progress and differentiation of function in the future of hu-

manity's advance. The areas of the more unused half-brain (the right in the right-handed, the left in the left-handed) occupied by the speech and writing centers in the more active half, show microscopically no failure or weakness of part or mechanism. If they did heredity would long since have eliminated the left-handed, and the right half-brain would become changed and atrophied except in those parts originating the muscular activity of the right side of the body. Possibly, the recurrence itself of the two or more per cent of left-handed persons prevents the atrophic tendency in the right-handed. Left-handedness is therefore probably not decreasing, and the forming organisms of the infant may become left-handed, etc., with no want of perfection in any part. The emergency finds the inherited mechanism ready for its task.

In this light and by reason of these facts one sees that materialism is absolutely disallowed. The speech and writing mechanisms of the brain do not as such exist, even functionally, in the fetus or newborn child. They are creations, slow creations, during childhood and youth. At any time they are instruments and mechanisms, expertly manufactured by something not themselves, used as a piano-key and string, and as all the keys and strings, as the piano itself, by something that plays upon them just as a pianist plays upon his instrument. That the instrument can or does make itself, that the player and piano are indistinguishable and of one substance, are the most unwarranted of pseudophilosophic assumptions. Far better than either philosophy or religion, physiology thus demonstrates the existence of the life and spirit of man, apart from the material of his body and its mechanisms.

There is much obscurity and misconception as

to what really is the nature and fact of right-handedness, right-eyedness, etc. The crudest blunders, for instance, exist even in learned monographs as to right-footedness. In dressing, a dextral man begins by first putting his left foot in the left trousers-leg; he places his left foot upon the spade or shovel; he jumps from the right foot; kicks with the left; the boxer and prize-fighter places the left foot and arm forward; the rider vaults a horse from the near side, and with the left foot in the stirrup first;¹ the entered apprentice mason "steps off with the left foot first"; all soldiers, since time began, start the march by first advancing the left foot. All of these things are conclusive proofs of right-footedness, and not of left-footedness, as many claim. The right foot and leg are unconsciously chosen as the strongest, the most steady, best co-ordinated, most expert ones, with which the spring, the determining or force-giving factor, is made. It is of course nonsense that animals are right-footed or left-footed. The differentiation could only arise with sign language and counting, and animals do not make gestures or count. No doubt that right-footedness in man is not so far advanced as right-eyedness and right-handedness; there are more exceptions, less differentiation of function, etc., but it is essentially present, and in process of evolution.

Right-eyedness is also subject to more exceptions than right-handedness because of the peculiar liability of the right eye to be thrown out of its function as the "dominant" one, or leader, by many ocular diseases, by injuries from blows, and

¹In the *Art of Horsemanship* Xenophon gives the most detailed instruction as to the method of mounting the horse, after which he says, "I think it good that the horseman should practice springing up from the off-side as well, on the chance that he may happen to be leading his horse with his left hand, and holding his spear in his right," etc.

especially by a more disabling optical defect (astigmatism, hyperopia, etc.). The struggle of nature to preserve the dominant function of the right eye is patent in the case of nearly every patient that comes into the oculist's office. The right will preserve its acuteness even under a greater optical defect than that of its fellow; the left is the one more frequently diseased and lost, and even with lessened visual sharpness the right is often retained as the dextral one. For there is tragedy when from any cause the right-eyed man in adult life is made into a left-eyed patient. Every act and co-ordination and judgment becomes slower, more awkward, more difficult and more inexact in result, because the visual factor in every act (and even every thought) is furnished by the opposite far-away and more inexpert center. There are few greater afflictions than one I now am witness of — paralysis of the upper lid of the right eye in a right-eyed person occurring in full adult or late life. The most amazing consequence of right-eyedness is lateral curvature of the spine. Approximately about 20,000,000 of the people of the United States have lateral curvature of the spine, and of these about three fourths, or about 15,000,000, indirectly owe their disease to right-eyedness. The deforming and crippling writing position which causes the deformity of the 15,000,000, is due to the necessity of bending the body and head to the left in order that the right-eye may see the pen point. The right eye must see the intellectual thing written even though the distortion of the back and tragedy of a life result!

When a right-handed person is made into a left-handed one by a broken arm, or by the equal misfortune of a foolish parent wiser than nature, the results are almost sure to be baneful. If

undertaken early enough in youth, the foolishness of trying to train the right hand by whipping, tying up the left, etc., may sometimes succeed, but at the expense of a life of trial, handicap, or even wretchedness and disease. Ill success in life is often caused by this folly. It is chiefly the writing act that arouses the sorry parent and the ambidexterity-crank to their impertinent opposition. But it is precisely the writing act which locates the speech center in the side of the brain opposite the writing hand. Writing, bound up with speech and memory, is the demonstrated origin of the localization of the speech center. Science, disease, physiology, tumors of the brain, etc., have proved that one may be left-handed in everything except writing, and that the speech center is in the left half-brain. I have a patient who, as a boy, was cruelly compelled to stop writing with his left hand, and after years of torment he was made a dextral writer. And for forty years he has never been able to think and write at the same time. He cannot write the simplest letter that requires thought, planning or judgment. He sends miles or waits hours for a stenographer, and can dictate the most technical engineering plans with clearness and rapidity. Another patient has been made mentally morbid, and a life of invalidism has resulted from the same cause. In the United States there are about two million originally or persisting left-handed persons, a portion of whom are mental and even physical cripples from the injudicious antipathy of parents or teachers to the "south-pawed." In comparatively few cases is the attempted change entirely successful. They have a sufficiently hard time to get left-handed work benches, tools, etc., and to pursue the avocations of the right-handed, without doubling their handicap by dividing the centers

required in a composite act between the two dissociate brain-halves. How pitiable is the lot of the left-handed soldier! I have two thorough-going left-handed patients who by training have learned to shoot a rifle from the right shoulder, but they depress the right eye below the gunstock and awkwardly sight with the left eye! When all his sinistral functions are performed by the left-handed man by means of the cerebral centers located in the right brain hemispheres he is as efficient, quick, intellectual, etc., as the right-handed person. The Jewish left-handed slingers, it is said, could cut a hair set up as a target. Because there are a few persons with the heart on the right side of the chest it would seem to be even more the duty of the ambidexterity societies and of officious parents to remove it to the left side by surgical operation! Let the left-handed child alone! Nature is quite as wise as the ignorant intermeddlers. For ages the stranger, the unknown and unusual person has been looked upon with dislike, and has even been persecuted because he differed from the one without other excellencies than that of being like his neighbors, or like the majority of them. The dislike of left-handedness is a relic of the same vicious egotism. The left-handed person is stupidly charged with being "sinister" and unlucky, and all because ages ago to the left or shield hand was given the natural task of protecting the heart and life of its master!

And a little quiet and unprejudiced observation would have shown that it is rather a division of tasks, a happy and advisable differentiation — not subordination — of function, that is coming about in the jobs which the left hand is commissioned to do. In the sterling old tasks of shoveling, pitchforking, chopping with the ax, etc., the

left hand almost divides the honors equally with the right. In locomotive-engineer driving, it is indeed the left hand that is on the throttle valve. Especially in the musician's art both hands must be equally expert and active. The fingering of the left hand of the violinist is technically as fine and dextrous a task as the bowing of the dextral hand. It is of vast significance that all tasks should be divided up and allotted to each hand, each eye and foot (perhaps to each ear?)—all except the one of intellect bound up with writing, speech and memory, which, necessarily single, must be shocked into action by a single and not a duplicated set of organs, which are placed only in one cerebral hemisphere. It is of no advantage to be able to eat with the knife or fork with each hand alternately and equally well; it is a positive disadvantage. Should every musician have two pianos, one as now constructed and another with the bass keys on the right, and should he learn to play equally well upon each piano? That is what ambidexterity means. The poor left-handed person is already almost entirely shut out from any musical calling, except that of singing, and there are many other avocations in which he is handicapped or doomed to failure. From this point of view one may wonder if the number of the left-handed will not decrease in the struggle for existence in civilization's progress of the future. There are no statistics to help us decide the question. The exclusion of such unfit ones will at least be only hastened by any interference with nature's production of left-handedness. With a very few years in childhood of nascent right-handedness or left-handedness started, the habit becomes so fixed that years of punishment, derision, strapping up the left hand and other methods of torture are utterly powerless to alter the devel-

oping and educating speech center in the right brain.

The bleatings, mooings, bellowings, roarings, etc., of vertebrate animals, together with the cries of the infant during its first months of life, are not language, or even the beginnings of language. Whether they express or are understood to express desire, pain, anger or passion, they are the voice, or suggestion of the voice, of the organism as a whole, undifferentiate, non-intellectual, — the cry of the abstract physiologic machine, wanting or pained, and as a unit; they are not inspired or guided by vision or by definite motived act. The air issues from the caverns of appetite and emotion, and in passing through the upper organs of respiration is slightly transformed into inarticulate sound. The vegetal or automatic organism is its origin and end. If innervated by the cortical centers these cries probably spring from a bilateral origin. Only when they become purposive in the slightest degree, when the other senses, and especially sight, are called in to furnish data and help for the motived and designed act, does the innervation of phonation arise in a single or one-sided center; the continuous evolution of the speech center thus becomes established and progressive. The "precise" but indefinite time at which this monolaterality begins is the "precise" but indefinite time when inarticulation becomes articulation. Articulate phonation is the intermediate of specialized and designed acts; it is the voice of intellect, choice and purpose. It is compositely formed out of the factors of sight, feeling, hearing, etc., furnished by individual, topographically placed, and neighboring cerebral centers. In a certain individual right-eyedness is doubtless the determining factor in localizing the developing speech-center in the left

half-brain. The individual misfortune, possibly tragedy, comes from a compelled change of plan after the localization on one side is under way, or established. A higher error of refraction in the right eye, or the results of disease, such as keratitis, conjunctivitis, squint, etc., may bring about the misfortune. To produce left-eyedness, when obviable, by reckless operations is, in the surgeon, a scientific blunder. To will and compel right-handedness in the naturally left-handed is a crime.

Physiologically, therefore, the reason why an infant puts forth the right hand to grasp objects is because the right eye is the one which is nearest perfect visually, anatomically, or optically. The law derived from the phylum of the entire past is that the right eye and right fore-foot, or right hand, must work together. In all animals the right eye governs the placing and action of the right front foot of the right side of the body, the guarding against dangers on the right side, etc. The left eye has the same office for the left side. Heredity has place in the creation of the more nearly perfect right eye. If the left eye of the infant is the better seeing eye it will grasp at objects with the left hand, and become left-handed. Handedness, if one may devise the word, becomes either right-handedness or left-handedness, according to the dictating condition of the better eyedness, right or left.