Scientific Proof of Brain Damage*

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INTRODUCTION

The human brain works effectively only when it operates within certain limited ranges of variation from fixed physical and chemical standards. When these limitations are exceeded, altered brain function occurs. At first, the changes are reversible, but when the excesses are great or prolonged, alteration in the fixed structure of the brain takes place, and this type of alteration is irreversible in nature.

It appears worth while to consider the various types of medical evidence which indicate that damage to the brain has occurred. In this account the emphasis will be placed upon the kinds of evidence and their evaluation rather than upon categories or classes of medical illnesses or injuries. It will be necessary to consider the brain in general and as a whole in order to avoid the extensive use of medical terms. Finally, mental phenomena will be given consideration only as they are concerned with brain damage, thus omitting the large field of mental illnesses which are commonly considered to be occurring in the presence of normal brain structure.

The detection of brain damage is often a difficult task and there are at least three reasons why this is true. First, the structure of the brain is extremely complicated and so is its function; second, the interrelationships of the brain and mind are very complex; and third, society accepts a considerable range of variation in human thinking and behavior as average, acceptable or "normal." The combination of these three elements makes the subject of scientific evidence of brain damage a very difficult one to present.

The human brain is composed of over ten billions of units which are called neurones or nerve cells[1] and each and every one of these cells has from many up to hundreds of processes or points of potential contact with other nerve cells. Just how these billions of cells are arranged into connected patterns of infinite complexity,

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[1] A neurone or nerve cell is a very small object, especially in its diameter which may be even less than 1/5000th of an inch. A neurone might be thought of as a spider-like form with some of the "legs" being greatly extended, even to a distance of two or three feet. Hence, many of the neurones are like very fine threads.

as they must be, is not completely understood at the present time. However, medical scientists feel that it is the intermittent and changing use of these complex nerve cell patterns in variable time sequences that constitutes the parallel brain activity for what is called mind or mental function.

There are reasons for rejection of the dual classification of normal and abnormal in the evaluation of brain activities but some scheme must be employed to separate those brains which work with more or less efficiency from those brains that do not. The difficulty comes when one tries to draw the line in terms of scientific evidence beyond which one can say that a measurable, unusual alteration has occurred in the brain. There are undoubted modifications in brain structure, of certain degrees and kinds, in persons who continue to consider themselves to be average or well from a medical standpoint; and competent and responsible from a legal one. It is necessary to classify such persons as normal and to exclude them from groupings which denote mental abnormality, illness or incompetence. The time of the evaluation is also important, for there are individuals with certain types of well established defects in brain structure who show changed thinking and behavior in a partial or an intermittent fashion. In such cases the impairment is detected only when their activities are measured by certain types of tests and at special times.

In very simple terms, it may be stated that mental dysfunction and incompetence can arise from two types of backgrounds; or from a combination of the two. First, mental impairment may follow the loss of brain cells; and second, mental impairment may be due to sociological needs and stresses which predetermine the misuse of the intact brain structures. The former causation, the loss of brain substance, is the one that is more likely to have legal repercussions, while the latter is more likely to represent long term conditions that have had their beginnings in unusual experiences in infancy and childhood. The separation of the brain damage (organic) conditions from the so-called psycho-social (functional) ones is a very difficult matter and any form of test or measurement that will help in this separation is the point of interest in this paper.

For purposes of accuracy and clarification, it is necessary to state at this point that it is possible for actual brain injuries (and for physical injuries to other parts of the body also) to play some part in the facilitation of the so-called "functional" mental illnesses. That is a matter which is outside the scope of this paper.

In an attempt to cover this broad subject of evidence of alteration in the brain, it appears that the material can be covered most adequately by using three approaches, the anatomical[2], the physio-

[2] Anatomical refers to anatomy which is the study of the structure of the body.

logical[3], and the psychological[4]. It is to be strongly emphasized that these three approaches are only arbitrary designations, and that their principal value lies in the fact that different techniques are used in these three disciplines. In many cases of alteration in the brain a single approach will not give incontestable evidence of the impairment. Quite often the opinion that significant alteration either exists or does not exist has to be based upon pieces of evidence obtained from one or more of the various anatomical, physiological and psychological techniques. It is to be remembered that all three approaches seek to measure the same object, the brain, it being only the method or procedure which differs, and the important objective is to correlate the results of the various test procedures.

Anatomical Evidence

Anatomical evidence has a certain concrete reality since it is objective in nature. However, the medical significance of anatomical or structural changes must be evaluated by a physician who is well versed in the structure of the body, both in health and in disease.

The degree of intactness of the anatomical structure of the brain of a living person can only be evaluated in a very gross manner. The outer aspect and the inner cavities of the brain can be outlined by the procedure of pneumoencephalography (air-encephalography).[5] The inner cavities or ventricles[6] can also be visualized by the more specialized procedure of ventriculography.[7] Regular x-ray pictures may show the appearance of foreign material in or around the brain, the effects of pressure on the brain, or the displacement of some of its parts. The cerebro-spinal fluid[8] may be

[3] Physiological refers to physiology which is the study of functions of the body.

[4] Psychological refers to psychology which is the study of the mind, and of thought and behavior.

[5] Pneumoencephalography (air-encephalography) is a procedure which consists in the removal of the watery cerebro-spinal fluid which normally surrounds and fills the brain, and the replacement of this fluid with air or helium. X-rays are then taken of the air or gas, thus delineating the boundaries of the brain. The air or gas is soon resorbed as the normal cerebro-spinal fluid reappears.

[6] The ventricles of the brain are odd-shaped cavities within the brain. They are normally filled with cerebro-spinal fluid.

[7] Ventriculography is a surgical procedure which consists of making small openings in the sides of the skull, through which a needle is inserted into the brain ventricles. The cerebro-spinal fluid is then withdrawn; air or a gas is injected, and X-ray pictures of the ventricles are taken.

[8] The cerebro-spinal fluid may be considered as a buoyant water bath for the brain and spinal cord. The fluid has normal average values for its pressure and its contents. These values are measured, commonly, by performing a spinal or lumbar puncture in which a needle is passed into the fluid space as it extends down into the lower back region.

withdrawn and analyzed for unusual constituents. Finally the blood vessels of the brain may be identified and measured by the technique of angiography[9].

Skull X-rays. The demonstration of a fracture of the skull by the use of x-rays strongly suggests that the brain has also been injured. It is probable that 80-90% of patients with skull fractures will show some evidence of brain damage when they are evaluated by other techniques, but the kind and amount of damage will vary from case to case. On the other hand, the absence of skull fracture following a head injury that was sufficient to cause unconsciousness does not rule out the possibility of brain damage. It is probable that at least 30% of patients who have had head injury with more than momentary unconsciousness will have some degree of brain injury.

When skull x-rays are used to establish that there is probable alteration of brain structure, attention should be given to the following diagnostic points.

There are many kinds of skull fractures and the individual case should be described with care. There is a great variation in the extent and the location of fracture lines in skulls. Breaks in the sides and top of the skull that occur as a single line (linear fractures) and those that do not cross the course of large underlying blood vessels are the least dangerous, while those that go across the midline, or occur in the temples or at the base of the skull are more serious. The escape of the watery cerebro-spinal fluid from the nostrils or ears, following a head injury is positive evidence of fracture through the base of the skull even if the fracture cannot be seen in an x-ray picture. Linear skull fractures must be differentiated from blood vessel channels in the bone and this is "occasionally difficult or impossible."[10]

Multiple breaks in the skull (comminuted fractures) are of much more serious import than linear fractures. Some of the fragments of these fractures are often depressed against the brain and may either irritate or destroy brain tissue.

An enlarging mass within the head such as a blood clot or a tumor may press upon, displace and damage the brain substance. This may be detected by a widening of the sutures[11] of the skull,

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[9] Aniography is a technique in which a contrast dye is injected into a blood vessel supplying the brain, and the dye is then photographed in X-ray pictures as it courses in the blood vessels in and around the brain.

[10] BROCK, INJURIES OF THE BRAIN AND SPINAL CORD AND THEIR COVERINGS 436 (*3rd. ed.* 1949).

[11] Sutures are the lines of junction between the bones of the skull.

by a displacement of the pineal body[12] if it is calcified and casts a shadow on the x-ray film, or by the appearance of calcium deposits in the enlarging masses themselves.

Cerebrospinal Fluid. A laboratory examination of the cerebrospinal fluid may give valuable evidence of brain damage, especially when such damage is of recent origin.

The finding of blood in the cerebrospinal fluid may indicate very recent pathology either in the brain or spinal cord or their coverings (the coverings are called meninges). Before this finding can be considered as highly significant, all of the samples of fluid that are removed should contain blood. If only the first portion of the fluid that is withdrawn is bloody, it is probable that the blood is coming from a vessel that was damaged in making the spinal puncture.[13] Therefore, the statement, "There was blood in the spinal fluid," may be misleading. Serial studies on the composition of the fluid on successive or alternate days may give evidence of the course of an injury. After a few days the bloody fluid (pink or red) is replaced by a brownish colored fluid or by clear fluid, provided the bleeding has not continued.

An increase in the pressure of the cerebrospinal fluid is an indication of a disease process that is occupying space within the head either in the form of a mass lesion,[14] a diffuse accumulation of blood or other fluid, or inflamed or swollen tissues. More chronic forms of brain damage may be accompanied by an increase in the protein content[15] of the cerebrospinal fluid and by the presence of an increased number of free cells,[16] the exact nature of which may give an indication of the type of pathology.

Pneumoencephalography and Ventriculography. These techniques are valuable in demonstrating the loss or absence of brain tissue which may result from failure in development, from shrinkage of the brain due to injury or disease, or from focalized encroachments upon the brain by lesions that occupy space.

Loss of brain substance may be manifest by an increase in the size of the cerebrospinal fluid spaces around the brain, or of

[12] The pineal body (gland) is located near the center of the head. It is about the size of a pea and frequently becomes calcified, and therefore casts an x-ray shadow, in later life. Thus, it may be used as a landmark in head x-rays if it is calcified.

[13] Spinal (lumbar) puncture is the tapping of the cerebro-spinal fluid by inserting a needle between the lower lumbar vertebrae into the fluid space as it extends below the inferior end of the spinal cord.

[14] A lesion is an hurt, wound, or local deterioration or loss of body structure.

[15] The protein content of cerebrospinal fluid removed by lumbar puncture ranges from 15 to 45 milligrams per cubic centimeter of fluid.

[16] The number of cells in the cerebrospinal fluid ranges from 0 to 3 or 5 per cubic centimeter of fluid.

those within the brain (ventricles), or of both. The increase in the size of the fluid space around the brain is more likely to indicate atrophy (wasting) of the cortex[17] of the brain than is the increase in the size of the ventricles alone. A widening of this outer space is also more likely to be corroborated by signs of damage in the brain wave test (electroencephalogram),[18] than is the case when only the ventricles are increased in size. The distortion of one brain ventricle, especially the one on the side of a previous head injury, is especially diagnostic of traumatic alteration in the brain.

The size and shape of the fluid spaces inside and around the brain vary within rather wide limits in normal and competent persons and therefore it is often difficult to be certain when loss of brain substance exists.[19] An increase of the fluid space over the surface of the brain to a width of more than four millimeters (approximately 1/6 of an inch) has been considered abnormal for an adult.

It is not easy to relate the abnormal findings of the pneumoencephalogram to a specific injury or disease. The age of the patient, his previous condition of health, the history of the incident in question, the subsequent clinical course of the patient, and the findings from other lines of investigation are all of value in deciding whether the findings in a pneumoencephalogram are significant in a particular case. It is to be remembered that pneumoencephalography is a gross technique and that the air encephalogram may be normal in the presence of considerable brain damage, even in a patient in whom the brain damage is accompanied by impaired mental function.

Angiography. The angiogram is a picture of an injected blood vessel as it appears on an x-ray plate. The technique is quite valuable in localizing lesions within the brain, especially tumors, and in establishing the type of tumor which is present on the basis of the individualized appearance of the blood vessels. The technique of angiography is not infallible, and may not be as helpful as ventriculography in finding tumors which lie centrally and inferiorly in the brain.

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[17] The cortex is the outer layer or covering of the cerebral hemispheres which form the larger parts of the brain. The cerebral cortex contains some fifteen billion nerve cells and is the most complicated and most important part of the brain.

[18] An electroencephalogram is a tracing which shows the electrical activity of the brain under certain conditions. It is recorded by attaching special small electrodes to the scalp and then using a complicated machine, an electroencephograph, to amplify the small electrical currents and change them into a written record. The procedure is painless and harmless.

[19] DAVIDOFF & EPSTEIN, THE ABNORMAL PNEUMOENCEPHALOGRAM 392 (1950).

PHYSIOLOGICAL EVIDENCE

The neurological examination and the electroencephalogram (brain wave test) are employed to obtain evidence of physiological nature that would indicate alteration in the brain.

In performing a neurological examination, the neurologist tests the capacity of certain nerve pathways, or reaction systems,[20] by causing stimuli[21] to discharge impulses[22] along these routes. The examiner then asks for the subjective impressions of the patient and he also observes the latter's objective behavior.

The important distinction between subjective complaints and objective signs must be remembered at all times. It is possible for a patient to manipulate his subjective account of complaints to his own advantage so that it will appear that he has suffered brain damage when such is not the case. This manipulation may be unconsicous on the part of the patient, as occurs in the neurotic use of complaints to meet personality maladjustments, or it may be conscious, as in malingering. Due to this uncertainty concerning the reliability of subjective data, the neurologist relies more on objective signs and findings, and especially on those which cannot be simulated readily.

The electroencephalogram or brain wave tracing is a record of the electrical activity of the outer aspect of the main part of the brain, that is to say, the cerebral cortex.

Neurological Examination. This should consist of the obtaining of a history, the eliciting of complaints, and the performing of the actual examination. The taking of the patient's history is an essential part of the neurological examination and a full and complete historical record may be every bit as important as the technical examination itself. In case of an injury to the brain, it is important to record the setting and the details of the accident or injury. In the case of a fall, the distance that the patient fell, the nature of the surface that he struck and the part of his body striking the surface should be carefully described. If a person was hit by a falling or moving object, that object should be described in detail including its nature, its weight, how far it fell or with what force it was being propelled. It is important to state whether the head was stationary or moving at the time of impact.

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[20] The nervous system (nerves, spinal cord and brain) is considered as consisting of linked nerve cells which form chains or pathways known as reaction systems.

[21] A stimulus is a change in the environment which causes a change to take place in one of the receptors of the nervous system. The receptors include such obvious structures as the retina of the eye as well as a huge number of less obvious free nerve endings in the skin and elsewhere.

[22] An impulse is a local chemical and electrical change that is discharged along the length of a nerve cell or neurone.

The loss of consciousness following an injury should be described with care. It is rare for a skull fracture, or for actual brain damage to occur without an immediate loss of consciousness, but it can happen. On the other hand, abrupt loss of consciousness can follow an impact type of injury to the head (or to the feet or buttocks) without skull fracture, and without damage to the brain as measured by any scientific technique. In other words, a temporary loss of consciousness following injury is not in itself proof of brain damage.

The examiner needs to record the time of onset of unconsciousness, its depth, the length of the period of unconsciousness and whether the return to consciousness was abrupt or whether there was a period of stupor and confusion. A prolonged period of coma following a head injury is presumptive evidence of brain damage, especially if the return to full consciousness was slow and irregular. The memory of the patient after his return to consciousness should be studied with respect to his capacity, at that time, in terms of immediate recall. The existence of any retrograde amnesia[23] should be noted and the length of the period of anterograde amnesia[24] should also be stated. The length of each of these periods of amnesia is important in estimating the severity of brain injury (W. R. Russell);[25] in general it may be stated that the longer the period or periods the more severe the damage.

The occurrence of vomiting soon after a head injury is of considerable significance as an indicator of alteration in the brain. The passage of a clear fluid from the nostrils or ears may indicate an escape of cerebrospinal fluid through a fracture of the base of the skull and a tear in the outer covering of the brain. Rigidity (stiffness) of the neck following a head injury may indicate the presence of free blood in the cerebrospinal fluid or an even more serious condition of infection of the brain coverings. A careful investigation should be made to determine if there was any impairment to the blood and oxygen supply of the brain following an injury, and whether that impairment was due to local conditions in the head or to a partial occlusion of the airways in the mouth, throat and thorax.

The first step in actual neurological examination is an estimation of the state and degree of awareness of the patient in terms of how he responds to various forms of stimulation. Partial degrees of impairment of consciousness are to be noted and de-

[23] Retrograde amnesia refers to the loss of memory for events occuring prior to the onset of a given injury or disease.

[24] Anterograde amnesia refers to the loss of memory for events occuring after the onset of a given injury or disease.

[25] RUSSELL, TRAUMATIC AMNESIA. BRAIN, 69:280 (1946).

scribed in terms of a range of conditions from full consciousness to confusion, to stupor, down to coma (unconsciousness).

Examination of the pupils[26] of the eyes may give valuable information on the state of the brain. Ordinarily the pupils are regular and of equal size in the two eyes, and both become smaller in the presence of increased light stimulation or when looking at near objects. A dilated and fixed pupil on one side may indicate damage to the same side of the brain, although there are other conditions both in the eyeball and in the neck which may give a similar finding. In unconscious states both pupils are widely dilated and will not respond to strong light.

When certain conditions of the eyes and optic nerves[27] are eliminated from consideration, the testing of the visual fields[28] may give diagnostic information about lesions of certain parts of the brain.

The paralysis of one or more of the muscles which move the eyeballs leads to a complaint of double vision. The divergence of the eyeball or eyeballs is called strabismus and is an objective finding of value if it appears for the first time following a head injury.

Weakness or paralysis of one side of the face following an injury does not necessarily indicate brain damage, since the condition may be due to injury or disease of the involved nerve (the facial or seventh cranial nerve) in its long course outward through the skull or in the side of the face.

Damage to the vestibular apparatus[29] of the inner ear may result in the significant finding of nystagmus which is an irregular to-and-fro jerking of the eyeballs. There are other causes for this condition besides injury to the head. But in any event, true nystagmus cannot be simulated and it is an important objective finding. A damaged vestibular mechanism may be detected, in addition to the finding of nystagmus not present before injury, by studying the effect of vestibular stimulation through, rapid reading, watching a moving object, etc. If these stimuli cause falling, nausea, headache, eye pain or tearing, it may be an indication of damage to the inner ear or to the lower part of the brain.

When considering the possibility of damage to the deeper

[26] The pupil is the round opening in the center of the colored portion of the eyeball.

[27] The optic nerve is the main nerve from the eye to the brain and is a part of the pathway for vision.

[28] The visual fields are those portions of space that the various parts of the eyes can see, when the eyes are fixed in position.

[29] The vestibular apparatus is a delicate organ for balance and equilibrium. It is located in bone at the base of the skull and is a part of the internal ear.

parts of the brain, especial reference should be made to a large bundle of nerve fibers called the internal capsule of the brain. Damage in this region is identified by the combined appearance of changes in sensation and of paralysis of the opposite half of the body. This condition is called hemiplegia.

Since the focus of this paper is on only those cerebral alterations which are accompanied by impaired mental functioning and a loss of social responsibility, the primary consideration is with the cerebrum portion, especially the cerebral cortex.

The occurrence of a temporary interruption of brain function in the form of a blackout, fit, or convulsion is a common indicator of brain impairment. These events may occur at any time following a head injury but they may also be due to causes other than head injury. Such occurrences are more common in those injuries which involve a tearing of the coverings of the brain and of its cortex. Most convulsions appear on the basis of scars on the cortex of the brain, and the first seizure commonly appears after the first month following the injury and before the passage of the sixth month. It is important to take a history that will cover the possible incidence of spasms, fits, blackouts, etc., prior to the injury in question. It is also important to evaluate the occurrence of any additional injuries or infections occurring between the time of the injury and the time of the first blackout, fit or convulsion.

Damage to the cerebral cortex of the brain results in a characteristic inability of the patient to deal with abstract material. The brain damaged patient reacts more adequately to the so-called concrete aspects of his surroundings, that is to objects and persons within the reach of his senses. He is likely to be unable to recall or to think about objects or persons beyond his immediate environment. He also will have difficulty in dealing with such an abstraction as color when it is considered apart from specific colored objects that he can see about him at the time of the examination.

The neurological examination is also concerned with damage in the cortex as it may be reflected in terms of agnosia,[30] aphasia,[31] and apraxia.[32] Agnosia occurs when the memory screen of the cortex is no longer available for the identification of the incoming environmental signal. Thus one may see without knowing what he sees, as in visual agnosia. The same thing applies when one hears sound that has no meaning; the condition is then called

[30] Agnosia is a term applied to the inability to recognize the nature of a sensory signal from the environment.

[31] Aphasia is the inability to understand and produce language whether it be written or spoken.

[32] Apraxia is a term which is used to denote the loss of muscle movements due to damage to neural patterns of accumulated skills.

auditory agnosia. When a blindfolded patient is unable to perceive the nature of previously well-known objects while holding them in his hand, he is said to have astereognosis which is a form of skin and muscle sense agnosia.

Aphasia may be a direct result of agnosia or it may occur in a motor form due to damage of those portions of the cortex of the brain which have to do with the organization of patterns of language production whether the language appears as spoken or written words.

Apraxia may appear as a sequence to agnosia, since the loss of stored memory patterns used in knowing the environment will result in impairment in knowing how to deal with the environment. But apraxia also follows lesions to the anterior part of the brain where the stored patterns of skill are located. A patient who has this latter type of apraxia, that is a pure loss of motor skill, will have insight into his handicap and will be frustrated by it. He is likely to avoid displaying his defect either to himself or to others.

The Electroencephalogram. The electroencephalogram or brain wave record is a tracing of electrical activity from the brain, largely from the part known as the cerebral cortex. Certain "normal" values have been set up for the recorded appearance of this electrical activity as it is studied with standardized machines and under uniform conditions.

It has been shown experimentally that injury to the brain results in the appearance of certain patterns of electrical activity that are not seen in the "normal" tracing. These abnormal patterns of activity may appear over local areas of the cortex or they may appear diffusely.

A slowing in the rate of the frequency of the cortical rhythms[33] and an increase in the voltage of the electrical potentials are the most common findings to indicate brain damage. Slowing can also result from other processes that interfere with the life of these nerve cells in the brain, processes such as diseases that cut down the blood supply, the presence of unusual chemicals, and the absence of certain other necessary chemicals in the blood. In head injury it is more common for such high voltage slowing to be focalized over one portion of the brain, and in the case of a single blow to the head, it is much more likely for the slow focus to be on the side of the injury.

In cases of suspected traumatic alteration of the brain, the observer is usually handicapped by not having available a pre-illness or a pre-injury tracing of that particular patient to use as

[33] The most common frequency is the so called alpha rhythm which is around 10 "waves" per second (the range is from 8 to 13).

a baseline. The only way to compensate for this common lack is to take a series of records beginning soon after the occurrence of the brain disease or brain injury. If this procedure is carried out and if the changes that are observed in a series of tracings show some correspondence to the clinical course of the patient then it may be assumed that one is viewing the electrical aspects of brain disturbance. For instance, in the case of a single injury to the brain, a series of post-injury electroencephalograms are likely to show the greatest number of abnormalities in the first tracing with a gradual return to normal in subsequent records. In early brain damage cases, waves occurring at a rate of 1-4 per second are common; in older cases of brain injury the slowing is more likely to be in the 5-7 waves per second ranges. The earlier the rhythms return to normal following brain injury, the better is the prognosis.

An EEG that is taken two or more months following a head injury is of much less prognostic and diagnostic value, especially when there is no focalized abnormality. The majority of any transitory changes that could have been ascribed to injury will have already taken place, and the assumption that generalized abnormalities are evidence of a specific injury, in the absence of a pre-injury tracing, will be speculative. The finding of a focalized slowing in the EEG two or three months after injury should be correlated with the site of the injury, the presence of residual neurological signs, or the observation of focal seizures, before unusual diagnostic significance is attached to it.

Psychological Evidence

In this area, we may employ the psychiatric examination and various mental tests to detect evidence of brain damage.

The Psychiatric Examination. A psychiatric examination should consist of an adequate history, the complaints of the patient in his own words, complaints about the patient's thinking and behavior from other sources, and the examination proper.

In taking the psychiatric history it is very important to know the nature of the pre-injury personality and the techniques of personality adjustment which the patient used before he was injured. A history of previous neurotic[34] trends or illnesses, or of psychotic[35] episodes is of the greatest importance. The prior re-

[34] Neurosis (Psychoneurosis) is a condition of mental illness in which complaints are used, without the patient being aware of the mechanism, to express unconscious wishes or desires or as a defense against such wishes or desires (guilt reaction).

[35] Psychosis is a more severe form of mental illness than is neurosis. The psychotic individual does not deal with the ordinary reality of the average person. His thinking and behavior are the result of his unconscious needs and of his impaired contact with the real world.

actions of the patient to illness, injury and adversity should be described. It is important to inquire into the presence of any pre-traumatic episodes of loss of consciousness with or without convulsions. Also the examiner should learn if the patient formerly had any need to use alcohol or drugs and the specific effects of those chemicals on the person who is now the patient. The motor attitude of the patient is important, whether aggressive and resentful; or passive and in need of over-protecting sympathy and care. The previous social, marital, and economic adjustments of the patient should be studied with care.

The patient may have a severe social and industrial handicap due to neurosis or psychosis, even when there is no brain damage, but such a state may have quite different prognosis than one due to brain damage. The post-injury or post-illness care of the patient may be such as to either engender antagonism, feelings of neglect, and resentment; or it may be so enveloping and over-protective as to allow the patient to find an escape by regression into neurotic invalidism, with a multitude of complaints that have no basis in brain pathology.

In evaluating the mind or mental capacity of a patient, one measures function in three areas or aspects, although it needs to be stated that these three aspects are no more than arbitrary designations. First, there is the sensory or receptive side of the mind; second, the associative, intra-psychic or intellection field; and third, the motor or expressive aspect.

On the receptive or sensory side the psychiatrist looks for disorientation and confusion which is based upon impairment of conscious contact with reality. It should be determined if the patient has lost the ability to recognize the content of reality, especially the more complex and abstract portions of such a reality. The present is identified upon the basis of the memory storehouses built up from past experience and when these memory patterns are damaged or destroyed the present cannot be "created" as a subjective experience. When the memory bank in the brain is impaired, identification and retention of present experiences will show a scattering loss or defect. Recent experiences will be poorly remembered while older experiences may appear to be better retained. The latter phenomenon may be somewhat of an illusion since there may be considerable fabrication and romancing in the accounts of past happenings that cannot be verified or denied at this late date.

In the field of thinking, it is common to find slowing of the thought associations, random associations leading to a flight of ideas, or the repetitive use of a given association. Random associations may be based upon the sound of syllables, words or phrases

rather than on the meaning of the language symbol. The repeated use of a syllable or word is called perseveration and it is not uncommon finding.

In the field of expression one sees thinking and behavior that is not measured by insight. The patient no longer sees himself as he is becoming and he shows a lack of concern for the needs of others. He is unable to maintain a set pattern of response over a period of time. Hence, he lacks ambition and perseverance, while he may show spurts of "acting out" of inconsiderate behavior.

Mental Tests. As with most of the other techniques, there is no exact psychological or mental test for brain damage. Therefore, in the study of brain impairment, the results from a battery of tests are of much greater value than the findings from a single test.

The accretion of memories (learning) and the recall of memories involve almost all parts of the brain, so it is to be expected that tests of retention and learning ability will give results which correlate better with the status of the whole brain rather than with a certain specific location in the brain. In other words, memory and learning tests that give abnormal results are more likely to indicate generalized loss of brain substance than a localizing defect.

The so-called I.Q. tests have definite value in measuring the intellectual capacity but it is seldom that a pre-injury record is available for comparison. It then becomes necessary to attempt to interpret sub-test findings as indicative of deterioration. The test score of an injured person may also be evaluated in terms of his school history and former social and industrial capacity.

There is considerable difference of opinion as to how well the so-called projection tests like the Rorschach (ink-blot) Test measure cerebral impairment.

On the other hand, if a test is used to measure more specific items such as thought associations that are dependent upon space perception and memories, the ability to abstract in terms of numbers, or the ability to arrange dissembled, non-labelled pictures to tell a coherent story; then, these tests may give some indication of local brain damage. For example, when a patient who can see and describe each picture separately cannot arrange the dissembled pictures to portray a story, the test result is thought to indicate damage to the frontal lobes of his brain.

Summary

The collection of satisfactory proof of alteration of the human brain is usually a difficult task.

It is often necessary to gather bits of evidence by various techniques — anatomical, physiological and psychological, since a

single technique does not often yield unequivocal proof of brain damage.

It is most important to analyze every patient on an individual basis.

Some of the kinds of evidence for the existence of brain damage have been reviewed.

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