Temporal Lobe and Behavior: Klüver and Bucy’s Classic

Thomas C. Neylan, M.D.

The eponym “Klüver-Bucy syndrome” describes the polysymptomatic behavioral sequelae of bilateral temporal lobectomy. Heinrich Klüver, Ph.D., and Paul Bucy, M.D., were members of the famous Chicago Neurology Club, which had blossomed around Percival Bailey, a former student of Harvey Cushing. Klüver and Bucy of the University of Chicago were initially interested in studying how mescaline administration produced seizures and orobuccal movements similar to temporal lobe fits described by Hughlings Jackson. In 1936 and 1937, in separate procedures, they removed the temporal lobes of a rhesus monkey named “Aurora.” Although the procedure failed to eliminate the effects of mescaline, they observed dramatic and reproducible effects on behavior. They repeated the experiment in a larger series of monkeys and reported their findings in the report reprinted here. Specifically, they describe a pattern of “psychic blindness,” a tendency to examine all objects orally, “hypermetamorphosis” (a term coined by Wernicke to describe a compulsive tendency to examine every object), profound emotional changes with the loss of learned fear responses, and increased sexual behavior. The reader will be fascinated by the elegant and detailed descriptions of the profound changes in behavior. For example, the bitemporal-lobectomized monkeys placidly and compulsively approach all objects—including those that prior to surgery elicited profound fear responses, such as the tongue of a hissing snake. They examine all objects orally, including sharp objects and feces, and fail to learn from aversive conditioning. When allowed to freely explore a room, they compulsively move from object to object without rest. They demonstrate a dramatic increase in autosexual, heterosexual, and homosexual activity.

Klüver-Bucy syndrome has been described in humans with a variety of bitemporal pathology and is also associated with aphasia, amnesia, and dementia. The syndrome is crucially relevant to neuropsychiatry because it illustrates the pivotal role of temporal lobe structures such as the amygdaloid complex and hippocampus in the regulation of memory and behavior.

References

Preliminary Analysis of Functions of the Temporal Lobes in Monkeys

Heinrich Klüver, Ph.D.
Paul C. Bucy, M.D.

In previous communications we pointed out that the chief symptoms following bilateral temporal lobectomy in the rhesus monkey consist in “psychic blindness” (Seelenblindheit) or visual agnosia, strong “oral” tendencies, and profound emotional changes. Our results were primarily based on an analysis of the behavioral symptoms of a female rhesus monkey which had been studied for a period of four months following the operations. The type of disturbance analyzed in that case seemed to be similar to the “associative mind blindness” of Lissauer. It is true that the diagnosis “agnosia” can be only of practical importance and merely serves to raise a number of questions. A review of the clinical literature indicates that the more carefully a case is studied the more difficult it may be to decide whether there is really an “agnostic” or merely a “visual” defect, that is, whether the variety of “agnostic” symptoms can be reduced to disturbances of “elementary” or “higher” visual functions. Von Monakow and Mourgue even raised
the question whether the disturbances in the process of recognition commonly referred to as “agnosia” are the result of an emotional indifference of the subjects, or, in other words, whether “agnostic” symptoms represent merely disturbances in the affective sphere. In view of this situation, we can consider the “psychic blindness” and related symptoms, as described in our first report, merely the starting point for further analysis. It seemed desirable to produce, if possible, the same symptoms in a larger number of cases and to extend the behavioral analysis in certain directions in order to gain a better understanding of the nature of the disturbance following removal of both temporal lobes.

TESTING PROCEDURES

In addition to general observations on locomotion, drinking, eating, sleeping, and other forms of activity displayed by the animals while kept in cages, we made use of a variety of special tests. Most of these procedures represent methods or modifications of methods previously devised by one of us for analyzing the behavior of subhuman primates. With the exception of our first monkey, which was observed previous to the operations only generally, all animals were tested before and after operation. In case the operation was performed in two or more stages, the animal was also subjected to interoperative tests. In the following sections, we shall briefly indicate the procedures and test situations employed. A detailed description of the tests will be published later.

1. Investigation of Sensory and Motor Factors. In addition to utilizing conditioned differential reactions as indicators (see “Differential Reactions”), we recorded the reactions of the animal to various stimuli and test situations. Although in most instances quantitative data were not obtained, the tests were designed to enable us to determine at least the presence of gross sensory and motor defects. The procedures used have been briefly described in our first report. The investigation of visual reactions was confined to the following items: visual reflexes; the ability to appreciate differences in brightness, size, shape, distance, or position of objects; and visual field defects. For example, in obtaining data on visual acuity we utilized pulling-in reactions; the caged-in animal was required to pull in black or white threads a fraction of a millimeter in diameter and lying on a black or white ground or on surfaces exhibiting complex visual patterns. In determining visual field defects, various methods of “food perimetry” and the “hemianopic testing board” were used. The application of the pulling-in technique made it possible to obtain data on the speed of motor reactions, handedness, and various motor habits.

2. Determination of Lateral Tendencies. Two or more similar objects were placed before the experimental cage. In reacting to objects in a row, any monkey may display strong right or left tendencies; that is, it may tend to pick up or pull in such objects as pieces of food, strings, or boxes from the right to the left or vice versa. The test situations employed have been extensively used in a previous study of hemianopic monkeys.

3. Multiple Object Tests. Different objects were placed in a row on a table on a piece of cardboard or were suspended from a horizontal string running parallel with the front of the cage and then brought within reach of the animal. In some tests the animal could view the objects before they were placed within reach; in others they were kept out of view until presented. The rows of objects contained either one or more pieces of food or none at all. The objects presented included such items as objects made of glass, wood, paper, or metal; feces; live animals; toys; spots of moisture; and drawings made with ink or chalk. In most tests each object was different, but in some tests two or more of the inedible objects were alike.

4. Investigation of Reactions When Monkey was Free in Room. The animal was turned loose in a large room which contained pieces of apparatus and furniture, and on the floor of which had been placed various objects, including several pieces of food. During a thirty minute period the reactions were observed by the experimenter and an assistant, who sat in different corners of the room.

5. “Concentration” Test. The apparatus, previously described, consists essentially of a rotating platform on which the center of a board, 180 cm long and 3.5 cm wide, is fastened. The positions of the apparatus and the experimental cage were so adjusted that the monkey was able to reach one end of the rotating board for a short time every thirty seconds. A piece of food was placed on one end of the board and a nail or metal nut on the other. The animal could, therefore, obtain one edible and one inedible object per minute.

6. Pulling-in Tests. The tests either represented “string experiments” or required the pulling in of a box under different conditions. One, several, or all of the strings lying within easy reach of the monkey were baited with food or some inedible object. Different “string configurations” were obtained by varying the number, position, length, direction, and distance of the strings from each other.

7. Differential Reactions Established by Training. The techniques used, which have been previously described, included: a) the “form board,” for establishing reactions
to visual differences; b) the “automultistimulation reaction board,” with two plates for establishing reactions to differences in sound; and c) the pulling-in technique, with movable stimulus boxes for establishing reactions to differences in weight. It should be remarked that “form boards” with one as well as with two holes were used. In tests with the one hole “form board” the animal simply had to push aside the stimulus object, for instance, a circle, to gain access to the food. Differential reactions were established only in 4 of the 8 animals with bilateral temporal lobectomy and in monkey 16 (see “Subjects”). This was done partly in view of Munk’s results with dogs. It was thought desirable to have available a series of animals which had not been subjected to systematic training procedures. Monkeys 1, 5, and 6 were trained to respond positively to a circle and negatively to a square of the same size. In critical trials following the training, groups of equivalent and nonequivalent stimuli were determined. Monkey 8 was trained to react negatively to a sound, the sound being produced by a Cenco impulse counter, and positively to “silence.” Monkey 6 was trained to react positively to the lighter of two weights in the 1,050 and 350 g pair. Finally, monkey 16 was trained to respond positively to a circle instead of a square and to respond positively to a 1,150 instead of a 350 g weight.

8. Investigation of Reactions in the Presence of Animate and Inanimate Objects. The response of the animal to the presentation of single objects likely to elicit characteristic forms of behavior, especially emotional reactions, was studied. We employed such objects as a snake, a cat, a dog, a rat, a mirror, a metal stick (such as is used in transferring a monkey from one cage to the other), and a catcher (used in catching monkeys).

9. Investigation of Implement-Using Behavior. Analysis of the ability to utilize objects as “tools,” as previous studies have indicated, seems worthwhile only in the case of Cebus monkeys. The present series includes 1 Cebus monkey (case 5); all the other animals were macaques. Implement-using behavior was studied only in the case of the Cebus monkey.

SURGICAL PROCEDURES

We shall briefly indicate the procedures employed in temporal lobectomy. In all cases anesthesia was induced by intraperitoneal injection of pentobarbital sodium. A temporal osteoplastic flap was reflected downward from over the temporal lobe. The pia-arachnoid membrane was coagulated and then cut with the Bovie high frequency current just below and parallel to the sylvian vessels and transversely across the temporal lobe at the level of the anastomotic vein of Labbé, if it occupied its usual position, or at a point just posterior to the lower end of the central sulcus. A blunt spatula was then inserted along these lines of incision and the lobe, including its medial surface, removed. Bleeding was controlled with the Bovie cautery. Whenever possible, the tissue was removed in a single block, weighed, and preserved for histologic examination. The wound was carefully dried and the bone flap replaced. Muscle and scalp were closed with several layers of silk sutures.

Some of the animals have been killed, while others are still being studied. The brains of the animals killed have been or are being serially sectioned, and the sections have been stained both for myelinated fibers (by Weil’s method) and for cellular elements (with cresyl violet).

A preliminary microscopic examination, for instance, of the brain of monkey 4 has shown that the extirpation included Brodmann’s areas 22, 21, and 20, with the exception of the upper part of area 22 lying anterior to area 19. The uncus and almost the entire hippocampus were removed. Throughout the extent of the lesion only a thin dorsomedial strip of the hippocampus remained. Posteriorly, as the hippocampus turns dorsally toward the hippocampal commissure, about one-fifth of this structure remained. The basal ganglia were not damaged except for the amygdala, which had been largely removed, and the tail of the caudate nucleus, which had been removed or seriously damaged.

SUBJECTS

In the following list we have indicated the species, the sex and weight of the animal, the type and date of the operation and the date of death, if it has occurred. In 7 of the 8 cases of bilateral temporal lobectomy the operation was performed in two stages. In 1 case both lobes were removed simultaneously (case 8). Cases 9 to 15 represent animals in which the temporal lobes were severed from either the frontal or the occipital lobes or in which one or portions of one or of both temporal lobes were removed. In case 16 one temporal lobe was extirpated subsequent to removal of both prefrontal areas.

Case 1. A female rhesus monkey (Macaca mulatta), weighing 6.3 kg, underwent extirpation of the left temporal lobe on Dec. 7, 1936, and extirpation of the right temporal lobe on Jan. 25, 1937. The animal was killed on Dec. 7, 1938.

Case 2. A male rhesus monkey, weighing 3.8 kg, underwent extirpation of the left temporal lobe, on Feb. 1, 1937, and extirpation of the right temporal lobe on Feb. 23, 1937. The animal was killed on July 8, 1937.
Case 3. A male rhesus monkey, weighing 3.42 kg, underwent extirpation of the right temporal lobe on Feb. 4, 1937, and extirpation of the left temporal lobe on Sept. 17, 1937. The animal was killed on Oct. 27, 1937.

Case 4. A female rhesus monkey, weighing 3.36 kg, underwent extirpation of the right temporal lobe on Feb. 11, 1937, and extirpation of the left temporal lobe on Feb. 23, 1937. The animal was killed on March 18, 1937.

Case 5. A male Cebus monkey (Cebus capucina), weighing 2.82 kg, underwent extirpation of the left temporal lobe on Sept. 17, 1937, and extirpation of the right temporal lobe on Oct. 15, 1937. The animal is still living.

Case 6. In a male rhesus monkey, weighing 2.72 kg, the olfactory tracts were cut on July 22, 1938. The right temporal lobe was extirpated on Nov. 25, 1938, and the left temporal lobe on Jan. 27, 1939. The animal is still living.

Case 7. In a male rhesus monkey, weighing 4.65 kg, the left temporal lobe was extirpated on Dec. 20, 1938, and the right temporal lobe on Feb. 6, 1939. The animal is still living.

Case 8. A male rhesus monkey, weighing 4.9 kg, underwent simultaneous bilateral extirpation of the temporal lobes on Jan. 23, 1939. The animal is still living.

Case 9. A male rhesus monkey, weighing 4.04 kg, underwent extirpation of the first convolution of the left temporal lobe on April 14, 1938, and extirpation of the first convolution of the right temporal lobe on July 8, 1938. The animal is still living.

Case 10. A female rhesus monkey, weighing 3.17 kg, underwent extirpation of the second and third convolutions of the right temporal lobe on May 26, 1938, and extirpation of the second and third convolutions of the left temporal lobe on July 16, 1938. The animal is still living.

Case 11. In a female Java monkey, weighing 1.4 kg, the connections between the temporal and the frontal lobe were severed, i.e., the anterosuperior margin of the lesion produced by temporal lobectomy was duplicated, on the left side on April 18, 1938. Connections between the temporal and the frontal lobe on the right side were severed on July 19, 1938. The animal is still living.

Case 12. In a male rhesus monkey, weighing 3.07 kg, the connections between the temporal and the frontal lobe were severed on the left side on July 12, 1938, and on the right side on Sept. 27, 1938. The animal is still living.

Case 13. In a male rhesus monkey, weighing 3.2 kg, the connections between the temporal and the occipital lobe were severed, i.e., the posterior margin of the lesion produced by temporal lobectomy was duplicated, on the right side on July 13, 1938. The connections between the temporal and the occipital lobe on the left side were severed on Sept. 29, 1938. The animal is still living.

Case 14. A female rhesus monkey, weighing 4.36 kg, underwent extirpation of the left temporal lobe on Feb. 4, 1937, and was killed on May 17, 1937.

Case 15. A male rhesus monkey, weighing 4.2 kg, underwent extirpation of the second and third convolutions of the left temporal lobe on April 15, 1938. The animal was killed on April 23, 1938.

Case 16. A female rhesus monkey, weighing 4.22 kg, underwent extirpation of the left prefrontal area on Feb. 11, 1937, of the right prefrontal area on May 12, 1938, and of the left temporal lobe on Jan. 30, 1939. The animal is still living.

EFFECTS OF BILATERAL TEMPORAL LOBECTOMY

We shall describe the polysymptomatic picture as observed in the “bilateral temporal” monkey. It should be said first that the present investigation has essentially confirmed the results obtained in case 1. Such symptoms as were exhibited in case 1 can be observed immediately after extirpation of the second temporal lobe or after simultaneous removal of the two lobes, and although certain changes occur in the course of time, it is worthy of note that the picture found in case 1 about two years after the operations is in most of its characteristic features essentially the same as can be observed in the bilateral temporal monkey as early as twenty-four hours after the operations. We shall first describe forms of behavior which seem to indicate that the ability to recognize and detect the meaning of objects on the basis of visual criteria alone is either lost or seriously disturbed, although the animal exhibits no, or at least no gross, defect in the ability to discriminate visually. We have summarized this group of symptoms under the term “psychic blindness.”

“Psychic Blindness”

The bilateral temporal monkey shows a strong tendency to approach animate and inanimate objects without hesitation. This tendency appears even in the presence of objects which previously called forth avoidance reactions, extreme excitement, and other forms of emotional response. The animal tends to contact every object in sight and to examine it by mouth rather than by hand. In multiple object tests, the caged-in monkey, even when hungry, will pick up objects indiscriminately either one after the other or, by using both hands, two at a time. After an oral examination, the object, if inedible, such as a nail, a glass, a live mouse, feces, or a piece of sealing...
wax, is discarded, but if edible is immediately consumed. In general, all available objects are examined, even though the first object examined may be the only piece of food present among the objects presented and even though the row of objects lying before the cage may contain no food at all. In a given test situation, an inedible object which has been discarded after a first examination may be reexamined several times. If the row of objects contains, let us say, one piece of food and four inedible objects, the reexamination of such an object as an electric bulb or a socket may take place before or after the food has been picked up. If the same objects are presented again in the next test or on succeeding days the animal examines them as if they were being presented for the first time. In such a way, a given object may be examined again and again in the course of several months as if it had never been responded to before. The animal tends to examine all available objects, even if two or more of the objects lying in a row are alike. If the inedible objects are not removed after each test, the animal may frequently reexamine them not only between tests but also while a new series of objects is lying before the cage.

Although it has been our endeavor to present as great a variety of objects as possible in the various multiple object situations, we have not succeeded in finding any object which the bilateral temporal monkey did not want to examine. Objects are examined, no matter whether they are very large or very small, dead or alive, edible or inedible, moving or stationary, silent or noisy, solid or figures printed on paper. The monkey seems to be just as eager to examine the tongue of a hissing snake, the mouth of a cat, feces, a wire cage, or a wagon as a piece of food.

The tendency to respond indiscriminately to various objects not only appears in the multiple object tests but may be just as strong when the animal is left to itself in its home cage or when it is turned loose in a room. When in its home cage the animal may examine at random pieces of food, the food pan itself, stones, cigarette stubs and wires lying among the pieces of food, the head of a screw in the wall of the cage, and a chain hanging down from the door. If free in a large room the animal may contact and examine more than 100 objects in thirty minutes and may pass the pieces of food lying on the floor many times before picking them up. The examination includes such heterogeneous objects as a steel nut in a motor, an iron pipe, the tail of a monkey, a windowpane, the fingers, shoes, and stopwatch of the experimenter, and a piece of soap. When free in a room, the monkey again tends to reexamine most objects at intervals, so that a given object, let us say an iron pipe, may be examined a dozen times in the course of half an hour. It is worthy of note that the monkey never changes the position of any of the objects in the room and that even very small objects are not carried around. Occasionally an object may be picked up for examination, but then it is dropped at the same place. The animal in moving about behaves as if all available objects belonged to one general class, as if they were merely “something to be approached and examined.”

In the “concentration” test, in which a piece of food or a metal object passes the experimental cage every thirty seconds, the monkey picks up both the food and the metal object until it ceases reacting to both. The food is eaten, whereas the nail or the steel nut is discarded after an examination by mouth. In some experimental periods, both the food and the inedible object are picked up in 100% of the trials. Even after as many as 260 successive trials the monkey may remove the nail each time it passes, so that finally more than a hundred nails may lie on the floor of its cage. As a rule, however, the monkey is not content with removing and examining the metal object in all, or practically all, trials; it will frequently pick up a nail or a steel nut from the floor of the cage in the intervals between removing an object every thirty seconds. It should be pointed out that the normal monkey in this test situation will let the nail pass by in all trials or pick it up only the first few times.

In pulling-in tests, the animal tends to pull in the strings indiscriminately, no matter whether edible or inedible objects or no objects are attached to them. In fact, the monkey may first examine the cardboard on which the strings are lying, then one string after the other and, finally, after the pulling-in, the object fastened to the string. Again, the strings and objects already pulled in may be examined between trials. When pulling in boxes, the monkey may examine the string repeatedly during the pulling-in and the box itself before reaching into it.

Oral Tendencies
There exists a strong tendency to examine all objects by mouth. The fact that in the multiple object tests and in other test situations we have not discovered any kind of object the monkey did not want to examine means, therefore, that we have found no object the animal was not prone to examine orally. This oral examination consists in putting the object into the mouth, biting gently, chewing, licking, touching with the lips, and “smelling” by holding the object before the nostrils. At times the object is first put into the mouth and then “smelled”; sometimes the “smelling” occurs first. Either reaction is rarely absent in examining an object. Oral tendencies are present not only in the sense that the animal examines the object orally but also in that it tends to contact the object directly by mouth instead of using its hands. Even
in the multiple object tests, in which the objects are lying before the cage, the animal may often attempt to press its head through the bars to establish direct contact with its mouth. Since this is not possible, the monkey is forced to pick up the objects for oral examination. "Objects" which cannot be picked up, such as spots of moisture, drawings made on the table, or designs on wallpaper, are frequently touched, rubbed, or scratched after futile attempts have been made to pick them up. Such reactions are frequently followed by holding the hand or one finger before the nostrils. The "smelling" of fingers is also observed if an object is beyond reach so that no contact can be established by hand or mouth. Occasionally this "smelling" even precedes the touching or picking up of an object within reach. The monkey may repeatedly stick out its tongue to contact a metal object moving back and forth before the cage, although such an object can be easily reached by hand. The tendency to examine objects orally is not interfered with, of course, when the animal is turned loose in a room. The monkey will run from one object to another and contact and examine the various objects, or parts of them, by mouth. At times the reaction seems to be confined merely to "smelling" glass, metal or other objects, since the mouth does not come in direct contact with the object. When transferred to another cage, the monkey frequently first makes an oral examination of the door, chain, galvanized iron of the floor, heads of nails, or other parts of the cage. In the "concentration" test, the hundredth nail picked up is examined orally in the same way as was the first nail removed from the board. In pulling-in tests the monkey examines not only the various objects pulled in but also the stick or the hand of the experimenter used for removing these objects from the experimental cage after completion of the test.

The tendency to examine objects orally is present even though the objects may have acquired "meaning" through previous training. For instance, in the "form board" test the animal is required to choose a circle instead of a square. For the normal monkey which has learned this problem the circle merely points to, or signifies, the presence of food. It is not reacted to for its own sake. It is an object to be pushed aside to gain access to the piece of food. For the bilateral temporal monkey the circle does not signify another object, that is, food, but both circle and square are treated as any other object, that is, as something to be examined. At times both stimulus figures are picked up, examined by mouth and discarded before even an attempt is made to take the piece of food lying in one of the holes. When the automutilation reaction board is placed before the cage, the animal may try to contact the apparatus by mouth and, since this is impossible, may at least remove the brass squares, take them into the cage, and examine them orally.

It is of great interest that the normal rhesus monkey which gets hold of an inedible object is generally dominated by the tendency to tear it rapidly to pieces by using the hands and mouth. In contrast to this, the bilateral temporal monkey when confronted with a variety of objects evidences a certain lack of aggressiveness toward the objects in the sense that it confines its activities to biting them gently, to licking, or to touching them with the mouth; in brief, to examining them orally in different ways. The same type of reaction or, differently expressed, the same lack of aggressiveness toward objects appears when the animal is turned loose in a room. No attempt is made to destroy, break, or carry objects around.

The reactions, and especially the oral tendencies, observed in case 6 deserve special comment, as the olfactory tracts of this monkey were cut previous to removing both temporal lobes. After the olfactory tracts were severed, the characteristic gesture of "smelling" an object by holding it before the nostrils was still observed for a week. Thereafter, up to the present, for about ten months, the "smelling," even of pieces of food, has never been observed. After section of the olfactory tracts but prior to removal of the temporal lobes the monkey did not show any tendency to pick up inedible objects; even edible objects, in case the animal was not familiar with them, were frequently not taken. This type of behavior did not change when, after about four months, the right temporal lobe was removed. When the left temporal lobe was extirpated about six months after the olfactory tracts were severed, all of the symptoms characteristic of the bilateral temporal monkey appeared except that no "smelling" was ever observed. Although one of the components in the picture of oral tendencies was absent, it is significant that oral tendencies were present as in any other animal with bilateral temporal lobectomy. The results may be best illustrated by reference to the "concentration" test. After the cutting of the olfactory tracts, the animal picked up the piece of food in 100% and the metal object in 2% of the trials. There was never any "smelling" of the objects. After removal of the right temporal lobe exactly the same results were obtained. When the left temporal lobe was also removed the "smelling" reactions continued to be absent, but the animal now picked up the nail or the steel nut in 92% of the trials and in each case examined the object by mouth before discarding it. In brief, it may be said that the reactions observed in the "concentration" test, the multiple object tests, the pulling-in tests, and the other test situations clearly indicated that monkey 6 was not different from any other animal with bilateral
temporal lobectomy in its tendency to pick up objects indiscriminately and then examine them by mouth.

“Hypermetamorphosis”
Any description of the typical behavior of the bilateral temporal monkey is incomplete without reference to another characteristic reaction tendency. When the reactions of the monkey to animate and inanimate objects are observed, it frequently appears to the observer as if the animal were acting under the influence of some “compulsory” or “irresistible” impulse. It behaves as if it were “forced” to react to objects, events, and changes in the environmental stimulus constellation. Thus, it may be said that in the bilateral temporal monkey there exists an excessive tendency to take notice of and to attend and react to every visual stimulus. The symptom described here has been given various names by neurologists and psychiatrists, for instance, by Wernicke, Sommer, Leupoldt, Steiner, and others. For the sake of brevity, we shall adopt the terminology of Wernicke, who spoke of a “hypermetamorphosis” and a “hypermetamorphic impulse to action.”

The monkey immediately attends to and takes in quickly the various details of a visual situation. The close visual inspection is not confined to objects within reach. The objects singled out for inspection may include such items as an eyelet in a board, a speck of dirt on a mirror, a scratch on the table, a nut in a motor, a stone in a ring, the foot of a toy monkey, a whiff of smoke, cuff buttons, a wrist watch, and the mouth of the experimenter. When confronted with a series of objects, the monkey frequently looks from one object to the other before seizing one and often picks up two at a time. In the “concentration” test the animal may almost constantly attend to the end of a moving board and in such a way succeed in removing an object every thirty seconds for more than two hours. It seems clear, therefore, that a “paralysis of attention” or similar defects cannot be assumed to account for the picture of “psychic blindness.”

The outstanding characteristic of the various reactions is not that the monkey attends visually to such a variety of stimuli and evinces such great curiosity in all kinds of objects and events. The most impressive feature is that the presentation of any visual object will, whenever possible, immediately lead to a motor response. For the bilateral temporal monkey the most heterogeneous objects, varying from a dot in a necktie to the tongue of a hissing snake, have become equivalent in the sense that they evoke the same typical forms of motor behavior. Expressed differently, certain properties of the objects, their being “dangerous,” “inedible,” or “indifferent,” have suddenly become ineffective in determining visually guided reactions. The monkey seems to be dominated by only one tendency, namely, the tendency to contact every object as quickly as possible. The speed with which contact is established is especially great when only a single object is presented. Noticing an object and performing the requisite motor response for contact seem to be a continuous process. When turned loose in a room, the monkey often behaves as if it were ceaselessly “pulled” from one object to another. When the experimenter or a stranger enters the laboratory, the animal may be seen standing in its cage as near to the door as possible and with an arm extended in the direction of the person entering. If the monkey is prevented from establishing contact with an object by the experimenter keeping the object out of reach, it may start examining the objects available in its cage.

The “hypermetamorphic impulse to action” is set off by almost any kind of object. It seems, therefore, that the fact of an object being an object, that is, a “segregated whole,” a “discrete something” different from its surroundings, is in itself sufficient for eliciting this impulse. The multiple object tests and other tests demonstrate the strong tendency of the animal to respond to every available object, no matter what its character, and to reexamine it whenever it is noticed again. Whether or not an object is noticed, however, seems to depend on various factors. For instance, every attempt to remove one of the discarded objects from the cage may be immediately followed by grabbing and examining this or some other object or the hand of the experimenter. The monkey, which picks up, let us say, a nail for the hundredth time to examine it, is examining the same object, i.e., a nail, but the very fact that something is presented within reach, either by the experimenter or by an apparatus, makes possible what was impossible a few seconds ago, namely, a transformation of the “hypermetamorphic impulse to action” into action. At any rate, on appearance of the nail the monkey responds by picking it up.

Sensory and Motor Factors
The question may be raised whether the picture of “psychic blindness,” oral tendencies, and “hypermetamorphosis” results from a combination of various sensory and motor defects. It appears that defects in “elementary” sensory functions either do not exist or are of a kind not apt to account for the typical behavior of the monkey.

In cases of visual agnosia the attempt must be made to determine whether visual defects of various kinds can in some way account for the reactions observed. One of us\(^6\) has shown that visual field defects alone, even if they should exist, cannot be considered sufficient to produce the picture of “psychic blindness.” It was found that the various differential responses to visual stimuli
established by training were not lost, or were only slightly disturbed, after unilateral occipital lobectomy or bilateral destruction of the macular cortex. In these cases Brodmann’s areas 18 and 19 were also injured. Since in these cases even very extensive damage to the visual system did not lead to inability to recognize objects visually, it is difficult to understand why such a defect should appear as a consequence of much smaller field defects, as found in some of our bilateral temporal animals. In some cases of temporal lobectomy no field defects can be demonstrated. Yet the previously described symptoms following bilateral temporal lobectomy are the same in animals with and in those without visual field defects. In case 7 the tests indicate the existence of right homonymous hemianopia. The ability to appreciate differences in brightness, size, shape, distance, position, and movement is as little impaired in this monkey as it is in monkeys with the left occipital lobe removed.

Our previous analysis of case 1 made the existence of defects in the upper quadrants highly probable. Since then, the existence of these defects has been supported by anatomic investigation of the brain. When microscopically examined, the right hemisphere showed interruption of the ventral half of the visual radiation close to its origin in the lateral geniculate body. There was presumably a defect involving the upper homonymous quadrants of the left halves of the visual fields, extending probably as far as the horizontal meridians and including the macula. The functional defect to be postulated on the basis of an examination of the left hemisphere was far less extensive and was probably confined to the upper part of the temporal crescent of the right eye. Despite the defects in the upper left quadrants, the monkey would jump without hesitation from the floor to high stands or tables. Anatomic investigation of the brain in case 4 indicates that one must postulate a defect confined to the upper parts of the temporal crescents. Anatomic data on other cases are not yet available.

In studying visually induced reactions, the question is of interest whether the sequence of reactions in multiple object tests and other test situations is determined by strong lateral tendencies. Such right or left tendencies appear in normal animals, but especially in hemianopic monkeys when series of similar objects are presented. Lateral tendencies also occur at times in cases of bilateral temporal lobectomy, but our observations in multiple object tests and other tests, in which dissimilar objects are introduced, do not support the view that strong right or left tendencies, combined with an excessively strong impulse to action, enforce on the animal a certain sequence of reactions.

The temporal lobes have been of interest chiefly because of their importance for auditory function. In studying the anatomic relationship of the medial geniculate body to the cerebral cortex, Walker has found that in the rhesus monkey the medial geniculate body projects only to a small area on the superior surface of the first temporal convolution. It is of historical interest that work on the functional significance of the temporal lobes has really been concerned with this small area. In our operations no attempt was made to remove this area, since our interest in temporal lobe functions was aroused by the discovery of one of us (Klüver) that the injection of mescaline or chemically related substances into monkeys produces peculiar chewing and licking movements as well as convulsions, in other words, symptoms resembling those found in the “uncinate group of fits” described by Hughlings Jackson and Stewart. It was thought desirable, therefore, to remove the temporal lobes, including the uncus. In passing, it should be noted that the symptoms produced by mescaline are the same in the bilateral temporal monkey as in the normal monkey.

The bilateral temporal monkeys in our series did not exhibit any disturbance in auditory function if judged by the motor reactions to various sounds. Although quantitative data are lacking, it seems justifiable to assume that at least gross defects were absent. The anatomic data so far available support this view. In case 1 only the caudal tips of the medial geniculate bodies were degenerated. In case 4 the posterior one-fourth or one-third of the medial geniculate bodies was degenerated, the degeneration being more extensive on the right side. For several weeks, and even months, these animals do not vocalize; no sound is uttered in response to other monkeys. The monkey is likely to remain silent even if it is attacked or if the whole colony is shouting at feeding time. The vocal behavior which appears thereafter seems to differ from that of the normal monkey. The fact that the animals respond to and yet do not seem to recognize the meaning of sounds suggests the possibility of “agnosia” in the auditory field.

The possibility of a tactile agnosia must also be considered, although we failed to detect changes in cutaneous sensitivity in most cases. None of the monkeys was satisfied with touching, grasping, or manipulating the objects. Seizing an object was merely preparatory to transporting it to the mouth. With the methods at our disposal, it was difficult to obtain reliable data on the gustatory and the olfactory sense, but it is noteworthy that inedible objects were never swallowed. Inedible objects were always discarded after an oral examination, although even feces was often chewed several times before being removed. Nevertheless, the type and speed
of removing objects, such as feces, a piece of food soaked in quinine, or a wooden or metal object, were often strikingly different. In view of the fact that the lesions involved all or the greater part of the hippocampus and uncus, it is of special interest that the “smelling” of objects and the characteristic gesture of holding an object before the nostrils represent some of the most typical reactions of the bilateral temporal monkey. It is significant that such reactions were absent in case 6, in which the olfactory tracts had been cut.

The motor reactions involved in grasping, holding, picking up, and pulling in objects were essentially the same as in normal monkeys. In some cases abnormalities of gait were observed. Although the tendency to approach and contact every object seemed equally strong in all animals, there were considerable differences in the amount of spontaneous activity. All of the more active monkeys tended to perform “antics,” not only when they could not get certain objects beyond reach but also when they were left to themselves in their home cages. In our previous description of case 1 it was pointed out that we frequently observed a “sequence of gesticulations, involving arms, head, and most of the body.” These gesticulations and similar movement patterns in other cases are difficult to describe. The many peculiar movements executed by the animal while sitting, lying, jumping, or hanging from the top or sides of the cage frequently arouse the mirth of a casual observer. The monkey may repeatedly put both feet, or one foot and one hand, simultaneously behind its neck. It may jump around on the floor of the cage while holding on to one foot with one hand and then without letting the foot go may jump to the seat of the cage. In jumping from the seat to the floor, it may seize the wire mesh at the top of the cage first with its hands, then with its feet, and then may drop to the floor, landing on its hands first. It may swing and perform peculiar twists of its body while hanging with its feet from the top of the cage. It may grab one forearm with one hand and move both arms up and down. It may hang with its hands from the top of the cage and, after pulling its body through the space between its arms, may swing back and forth with its feet almost touching the floor of the cage. It may repeat such movement patterns many times and combine them in different ways. In fact, the general picture is that of a witzelsucht of the extremities.

**Emotional Changes**

In the bilateral temporal monkey we find either profound changes in emotional behavior or complete absence of all emotional reactions in the sense that the motor and vocal reactions generally associated with anger and fear are not exhibited. This change in affectivity is especially remarkable in view of the fact that care has been taken to use only “wild,” aggressive monkeys in this work.

The fact that the monkey approaches every object without hesitation, no matter whether it be a catcher, a large bull snake, or a strange person, represents in itself a striking deviation from normal behavior. Even bodily contact with an object does not produce avoidance reactions or other forms of behavior indicative of fear. Movements, for instance, of a live animal when being examined, or other forms of sensory stimulation may, because of their suddenness, lead to retreat, but often immediately thereafter a new attempt is made to establish contact with the object.

The typical reaction of a “wild” monkey when suddenly turned loose in a room consists in getting away from the experimenter as rapidly as possible. It will try to find a secure place near the ceiling or hide in an inaccessible corner where it cannot be seen. If seen, it will either crouch and, without uttering a sound, remain in a state of almost complete immobility or suddenly dash away to an apparently safer place. This behavior is frequently accompanied by other signs of strong emotional excitement. In general, all such reactions are absent in the bilateral temporal monkey. Instead of trying to escape, it will contact and examine one object after another or parts of objects, including the experimenter, strangers, or other animals. The experimenter may walk over to it, touch and stroke, and even pick it up. The monkey often confines itself almost entirely to examining objects which are on or can be reached from the floor. After being attacked and bitten by another animal, it may approach this animal again and again in an attempt to examine it.

While this is the general picture of emotional behavior, individual animals present differences. Expressions of emotions, such as vocal behavior, “chattering,” and different facial expressions, are generally lost for several months, but they may reappear. In some cases the loss of anger and fear reactions is complete. In case 6, for instance, the animal is restless and active most of the time, constantly attending to and responding to numerous stimuli, never resenting any form of handling, always eager to engage in playful activities with the experimenter or to follow him around the room. In fact, it may be said that the picture of normal “wildness” has been replaced by that of “hypomania.” The bodily expressions of emotions associated with aggressive tendencies can be observed in some monkeys after a few months. Although such a monkey, with teeth bared and ears laid back, may jump toward the experimenter as if to attack him, it will merely lick or otherwise examine the fingers of the experimenter. The animal may exhibit expressions...
of intense emotional excitement in case the floor is swept near its cage or a wagon rolled by, but the moment the monkey is allowed to contact and to examine the floor or the wagon, the anger expressions will immediately subside. It seems that emotional behavior, when it occurs, occurs chiefly in connection with events preceding or following the oral examination of an object, especially when the attempt to contact an object is thwarted.

Changes in Sexual Behavior
In some monkeys the increase in sexual activity is so marked and the manifestations of sexual behavior are so diverse that we are forced to include sexual changes among the symptoms produced by bilateral temporal lobectomy. Such changes are not immediately apparent. We have noticed them first three to six weeks after the operation. It should be noted that 2 of the monkeys in our series were killed before this period. Our observations are, therefore, chiefly concerned with male macaques.

The monkeys appear hypersexed, not only when with other animals but also when alone. The reactions to be recorded either are overt sexual responses or represent forms of behavior involving some sexual element. When the monkey is confined alone in a cage, the following states and activities can be observed: frequent erection of the penis, often without previous manipulation, the glans penis being clearly visible, or semierection, even while the animal is sitting quietly; long-continued licking and sucking of the penis, the animal at times apparently falling asleep with the penis in the mouth; manipulating or pulling at the penis or scrotum, even while the animal is standing; “yawning” (as seen in copulatory reactions) and, at the same time, manipulation of the genitalia while lying on the back or side; oral and manual exploration of the genitalia while the animal is in all kinds of positions, for instance, biting of the penis while swinging back and forth with the feet suspended from the top of the cage and with the hands pressed against the hindquarters; long-continued biting of the fingers, toes, feet, legs, and other parts of the body; grabbing the bars of the cage and pressing the hindquarters rhythmically against them, and “presenting reactions” on approach of an observer. Grabbing the finger of the observer may be immediately followed by general bodily activity and penile erection.

Whenever other monkeys are put into the same cage, various forms of heterosexual and homosexual behavior can be observed. The monkey may, for instance, copulate almost continuously for half an hour. It may leave the female only to mount again immediately. If two bilateral temporal male monkeys are put together, sexual behavior may take forms which make it necessary to separate the animals. One of the monkeys while lying on the seat of the cage may reach with one hand toward the floor to grab the erect penis of the other monkey and practically lift the animal from the floor. The animal which is being lifted may do nothing but utter a grunt. Or one monkey may grab the tail of the other and in pulling it across the edge of the seat incidentally break the tail. While one monkey mounts the other and performs copulatory movements, the other one may be seen standing with erect penis. Or both monkeys may lie on the floor and mutually explore each other’s genitalia. One monkey may ride on the back of the other and at the same time suck one of its ears. Although they frequently bite each other’s legs, arms, or tail, fights never develop, and injuries are merely the by-product of heightened sexual activity.

Since such striking manifestations of sexual behavior are completely absent in the normal animals of our colony and do not appear in unilateral temporal monkeys kept on the same diet and under the same conditions, or in monkeys with differently situated lesions, we feel justified in assuming that these sexual changes are dependent on removal of the second temporal lobe or simultaneous removal of both lobes."

GENERAL CONSIDERATION OF BEHAVIORAL CHANGES
Munk failed to produce “psychic blindness” in rhesus monkeys, and although he thought that he had succeeded in producing it in dogs, it was subsequently shown by a number of investigators that visual disturbances and field defects could account for the behavior of the animals. We have found a picture of “psychic blindness” following bilateral temporal lobectomy in the monkey. The importance of this result lies first of all in the fact that such a picture can be produced by a cortical operation in animals. At the start, questions such as the duration of the symptoms or the exact nature of the lesions are of secondary importance.

In studying the various reactions and reaction tendencies, we have arrived at a group of symptoms which we may consider “typical” for the bilateral temporal monkey. We are aware that the picture may be modified by a variety of factors. The animals in the present series were studied for varying periods, ranging from three weeks to about two years from the date of the operation. They differed in age, weight, sex, and other factors. Nevertheless, in all cases the typical symptoms, which we have briefly summarized under “psychic blindness,” oral tendencies, “hypermetamorphosis,” and emotional changes, appeared almost immediately and remained
remarkably constant for the periods of observation indicated. It is true that changes occurred, but that these changes were not more marked deserves special emphasis. For instance, the experimenter could at all times touch, stroke, or slap 6 of the 8 monkeys. Such treatment of the other 2 animals was not possible after several months, but their emotional behavior remained profoundly altered. Monkey 1, which was studied for about two years, tended during the last few months, in multiple object tests, to pick up food first and then to examine the remaining objects, but was inclined to pick up objects indiscriminately again when they were kept out of view until presented or when injections of mesecaine were given. It should be remembered that many of the objects used in these tests had been presented again and again in the course of previous experiments. In brief, even the long-continued study in this case revealed little change in the general picture presented by “psychic blindness,” oral tendencies, “hypermetamorphosis,” and emotional changes.\textsuperscript{13a}

In considering the polysymptomatic picture following bilateral temporal lobectomy, the question may be raised whether the various symptoms point to one basic defect or disturbance. Conceivably, any of the symptoms described may be indicative of a disturbance in some fundamental mechanism, so that all other symptoms could be understood by reference to one factor. At present, however, any attempt to reduce the variety of behavioral manifestations to one simple formula seems rather hopeless. To determine the mechanisms operative in the behavior of these monkeys further analysis is needed. Preliminary information was obtained in studying various conditioned differential reactions.

In the “form board” test, the monkey was required to react positively to a circle instead of a square. The normal monkey may learn this without even making one error if the tests are preceded by a few trials with a one hole form board. We shall briefly state the results in cases 1, 5, and 6. In case 1 training was started after removal of both temporal lobes. The animal acquired the differential response only with difficulty and after hundreds of trials. For a long time stimulus figures and food were responded to indiscriminately, but finally an errorless performance was reached. Monkeys 5 and 6, which had been trained before the operations, showed a marked disturbance of the differential response after removal of both lobes, but it was possible to reestablish the response through training. The same marked disturbance occurred in the reactions of monkey 8, which had previously been trained to respond negatively to a sound. However, when vibratory stimulation was included by use of a buzzer or a bell fastened below the floor of the cage instead of the original source of sound (a Cenco impulse counter placed at a considerable distance from the cage), the animal immediately obtained food in 100% of the trials by opening the proper receptacle of the automultistimulation reaction board. Only one of the responses established preoperatively was found intact after bilateral temporal lobectomy, namely, the response in case 6 to the lighter weight in the 1,050 and 350 g pair.

More important than these findings, perhaps, is the fact that we were able to demonstrate that the animals had not lost the ability to “generalize” when responding to visual stimuli. In the “form board” tests the properties of the stimuli were changed by introducing variations in size, brightness, color, and even shape (by presenting, for instance, an ellipse and a triangle instead of a circle and a square) or by substituting “figures” drawn on cardboard for the circle and the square. Despite these changes, all 3 monkeys continued to react positively to the circle or responded immediately to the curvilinear figure.

It may be said that the ability to respond to different objects in terms of such relations as “larger than,” “brighter than,” or “nearer than,” or such properties as “angular” or “curvilinear” implies “generalizations” of a very primitive order. It can be readily understood that adaptive behavior, as long as it occurs at all, presupposes the effectiveness of such properties or the existence of such primitive forms of “generalization,” and it is apparently for this reason that investigators have frequently insisted that the Beziehungsfunktion cannot really be destroyed by cerebral lesions.

In view of this situation, the results obtained in the Cebus monkey (case 5) are of special interest. The “form board” tests gave no evidence that the ability to “generalize” in responding to visual stimuli was impaired. At the same time, the ability to utilize objects as “tools” in obtaining food was completely lost. It is apparently one thing to recognize that a stick is “longer than” another one or “nearer than” a piece of food; it is another thing to recognize the “tool” character of a stick. As previous work indicates,\textsuperscript{9} being “longer than” and being a “tool” are properties which become effective at different levels of adaptive behavior. At any rate, monkey 5 was unable to solve even the simplest problem in which a piece of food lying beyond reach on the floor could be obtained by using a stick lying near the food and within reach of the animal. The response consisted in repeatedly making an oral examination of the stick and again and again reaching for the food with one hand. When different objects were available at the same time, such as a stick, a sack, a wire, or a leather belt, the monkey, instead of seizing one of them to obtain food in a few seconds, as it would have done in preoperative tests,
repeatedly reached for the food and walked around for half an hour or longer examining one object after another. None of the objects was ever carried around. It is of great theoretic interest to learn whether these results will be confirmed by future work on suitable animals.

EFFECTS OF OTHER LESIONS

The behavioral changes following the removal of one temporal lobe were studied in 8 monkeys (cases 1 to 7 and 14) for periods ranging from about two weeks to seven months. The extirpation of one lobe produced none of the symptoms characteristic of the bilateral temporal monkey. In some cases, however, there was a change in the direction of greater “tameness.” This seems significant in view of the fact that we have failed to observe a similar change in monkeys with occipital, parietal, or frontal lesions. There was no disturbance in differential responses established before the operation.

Furthermore, the forms of behavior typical of monkeys with both temporal lobes removed did not appear after 1) bilateral removal of the first temporal convolution (case 9); 2) unilateral or bilateral removal of the second and third temporal convolutions (cases 10 and 15); 3) severing the connections between the temporal and the frontal lobes (cases 11 and 12), or 4) severing the connections between the temporal and the occipital lobes (case 13). Only in case 13 was there uncertainty as to whether at least some of the symptoms existed in an attenuated form.

Of special interest are the results in case 16. The chief effect of removing the left temporal lobe subsequent to removal of both prefrontal areas was disappearance of the restlessness and the hyperactivity characteristic of the prefrontal monkey and a marked change in the direction of greater “tameness.”

COMMENT

In view of the fact that the anatomic study of the brains has not yet been completed, a detailed discussion of the relations between behavioral and neural mechanisms is out of the question. At this point it seems worth while, however, to relate some of the results of our behavioral analysis to data furnished by human pathology.

We may consider the outstanding characteristic of the behavioral changes following bilateral temporal lobectomy to be that they affect the relation between animal and environment so deeply. A monkey which approaches every enemy to examine it orally will conceivably not survive longer than a few hours if turned loose in a region with a plentiful supply of enemies. We doubt that a monkey would be seriously hampered under natural conditions, in the wild, by a loss of its prefrontal region, its parietal lobes, or its occipital lobes, as long as small portions of the striate cortex remained intact.

The fact that removal of both temporal lobes in the monkey may result in such profound behavior changes, particularly in the emotional sphere, becomes of special interest in view of the insistence of previous writers, such as Anglade, Takase, and Marburg, that the temporal lobes in man are in some way concerned with emotions or “affective tonus.” The possible significance of the temporal lobes for emotional behavior has also been brought out in recent discussions of the nonolfactory functions of the “olfactory” cortex. It should be recalled that our extirpations include structures generally represented as subserving some phase of olfactory function. Herrick expressed the view that the olfactory cortex may serve as a nonspecific activator for all cortical activities and that it may act on “the internal apparatus of general bodily attitude, disposition and affective tone.” In studying the rhinencephalon of the dolphin, Addison found that the hippocampus, fornix, mammillary bodies, and habenular and amygdaloid nuclei are present, although the olfactory bulbs and tracts are lacking. Langworthy made similar observations in the porpoise. It is of interest that the parolfactory cortex, which Edinger termed a center for the Oralsinn, was present in both forms. In the opinion of Langworthy, “the fact that the hippocampus, fornix, and mammillary bodies persist . . . suggests that they must have functions other than olfactory.”

The nonolfactory functions of these structures have recently been emphasized in a different connection by Papez, who attempted to find an “anatomic basis of the emotions” by correlating anatomic, clinical, and experimental data of various kinds. He stated:

It is proposed that the hypothalamus, the anterior thalamic nuclei, the gyrus cinguli, the hippocampus and their interconnections constitute a harmonious mechanism which may elaborate the functions of central emotion, as well as participate in emotional expression.

Papez suggested that “the central emotive process of cortical origin” may be built up in the hippocampus and transferred to the mammillary body and thence through the anterior nuclei of the thalamus to the cortex of the cingular gyrus, from which the process may spread to other regions in the cerebral cortex. He found “no clinical or other evidence” to support the view that these structures mediate olfactory function.

In our experiments, the cortical circuit proposed by Papez has been definitely interrupted by removal of the
hippocampus. The fact that none of the typical symptoms appeared in animals in which the hippocampus was left intact may also be interpreted as lending further support to Papez’ theory. As pointed out before, the behavioral reactions characteristic of the bilateral temporal monkey were absent when only the first convolution or the second and third convolutions of the temporal lobes were removed, or when the connections between the frontal and the temporal lobes or between the occipital and the temporal lobes were severed. Whether the hippocampal formation and its connections play such a decisive role in emotional behavior, as suggested by Papez, can only be determined by subsequent experimentation. To throw further light on the symptomatology of the bilateral temporal monkey, it will be necessary to study not only the effects of differently situated subtotal lesions but also the changes following a resection of the fornix or an isolated removal of the hippocampus. Herrick26 has called attention to the fact that most ablation operations performed in connection with studies of behavior have involved only the neopallium, leaving the olfactory cortex entirely intact or but slightly injured. He pointed out the necessity for removing the various parts of the olfactory cortex in an isolated manner, although this may involve “difficult, but probably not impossible surgical operations.”

Kleist20 has advanced ideas similar to those of Papez in proposing an anatomic substratum for enteroceptive functions, i.e., drives, attitudes, personality traits, moods and emotions. Spatz25 expressed doubt that the highly developed Orbitalhirn of Kleist and the primitive allocortical olfactory region are intimately related and emphasized the importance of the “basal cortex” of the temporal and the frontal lobe for personality changes. He advanced the opinion that no other disease is more important for advancing knowledge of cortical localization than Pick’s disease. In this disease there are not only fundamental changes in personality and character but also such symptoms as echolalia, echopraxia, and palilalia.22 Even in the last stages of the disease the patient may still visually attend to everything that is going on and seize every object within reach to put it into his mouth.23

In considering the “hypermetamorphosis” and “hypermetamorphic impulse to action” in the bilateral temporal monkey, we commented on the “compulsory” nature of the reactions. The question may be raised whether the lack of inhibition displayed in seizing every object and the tendency to respond to the same object again and again find their parallel in the symptomatology in cases of lesions in the human temporal lobe. It is perhaps significant that the analysis of speech disorders led Pick24 to the view that the temporal lobes form the anatomic basis of inhibition, the absence of which leads to logorrhea, various echo symptoms (echolalia, echo- graphia, echopraxia), and paraphasia. According to him, the speech utterances accompanying the epileptic aura or the “dreamy states” of Hughlings Jackson also involve the same mechanism of disinhibition.

In studying the similarities of catatonic and encephalitic disturbances in motility, Steiner25 found postencephalitic children who touched and examined every object in sight by hand without uttering a word. He expressed the view that a “hypermetamorphosis” which takes the form of touching and tactually examining every object is closely related to echopraxia and echolalia. It is of interest that Leyser,26 Lotmar,27 and others stated that “hypermetamorphosis,” profound changes in affectivity, and changes in sexual behavior are the outstanding symptoms in cases of epidemic encephalitis.

The fact that a picture of “psychic blindness,” as described by Munk, should result from lesions of the temporal lobe is not readily explained at present. The close relation of aphasis and agnostic symptoms has been frequently emphasized. It is known from Walker’s study of the thalamocortical projection of the rhesus monkey that the temporal lobe has few or no thalamic connections except from the medial genulate body.11 The functional significance of this observation is not clear, but it seems that the elaboration of impulses relayed from the periphery by way of the thalamus cannot be one of the chief functions of the temporal lobes. The importance of the corticifugal fiber connections of the temporal region, as studied by Mettler,28 must also be considered. Niessl von Mayendorf29 has advanced the theory that visual agnosia is due to lesions of the left macular bundle of the visual radiation or of the cortical representation of the macula in the left hemisphere. We consider it safe to assume that the picture of “psychic blindness,” as found in the bilateral temporal monkey, is not due to such lesions. The anatomic investigation, for instance, of the brain of monkey 4 has clearly demonstrated that both macular bundles are intact. The behavioral tests applied to animals still living definitely suggest that visual field defects do not exist in the majority of cases.

SUMMARY

The behavioral effects of the removal of both temporal lobes, including the uncus and the greater part of the hippocampus, were studied in macaques. The monkeys exhibited the following symptoms: 1) forms of behavior which seem to be indicative of “psychic blindness”; 2) strong oral tendencies in examining available objects (licking, biting gently, chewing, touching with the lips,
3) severing the connections between the temporal and the frontal lobes, i.e., duplicating the anterosuperior margin of the lesion produced by temporal lobectomy; 4) severing the connections between the temporal and the occipital lobes, i.e., duplicating the posterior margin of the lesion produced by temporal lobectomy. The symptoms also did not appear after unilateral temporal lobectomy, except that there was in some cases a change in the direction of greater “tameness.” This “tameness” was also observed when after previous extirpation of both prefrontal areas one temporal lobe was removed.

Differential reactions to visual stimuli established preoperatively were seriously disturbed after bilateral temporal lobectomy, but it was possible to reestablish the response through training. The ability to “generalize” in responding to visual stimuli did not seem to be impaired.

Notes
3. von Monakow C: Die Lokalisation im Grosshirn und der Abbau der Funktionen durch kortikale Herde. Wiesbaden, JF Bergmann, 1914
6. Klüver H, Bucy PC; Klüver H15
7. Klüver H, Bucy PC16; Klüver H17
8. Klüver H17; Klüver H, Bucy PC16
12. Hughlings Jackson J, Stewart P: Epileptic attacks with a warning of a crude sensation of smell and with the intellectual aura (dreamy state) in a patient who had symptoms pointing to gross organic disease of the right temporoparietal lobe. Brain 1899; 22:534–549
13. It is perhaps significant that in case 1 typical “presenting reactions” were frequently observed after a period of one and a half years in spite of the fact that the uterus and both ovaries had been previously removed. This animal, as well as 3 other monkeys that had had similar operations, were supplied to us by Dr. G. W. Bartelmez. Two of these animals were even “wilder” and more “vicious” than the average untamed rhesus monkey. Only 1 of these 4 animals was used in the present study (case 1).
13a. In checking on possible changes in dietary habits, we recently found that the rhesus monkeys with bilateral temporal lobectomy which are still living (monkeys 6, 7 and 8) eat animal foods, such as bacon, liver sausage, boiled ham, boiled tongue, smoked whitefish, ground beef and boiler lamb chops. We have never seen normal rhesus monkeys accept such articles of diet.
14. Spontaneous activity was registered by utilizing vacuum tube amplification. The floor of the cage was covered with pieces of galvanized iron separated by gaps of about 15 cm. A minute current passing through the body of the animal operated a relay controlled whenever the animal walked or ran across these gaps. In such a way the number of circling movements or other movements from one part of the cage to the other could be automatically recorded by an electric counter.