The result (Table 2) indicates that the majority of varieties are indeed very active in degrading malathion through carboxylesteratic hydrolysis as well as by desmethylation processes.

The precise mechanisms of the degradation of malathion by these microorganisms are uncertain at this time. The fact, however, that the carboxylic acid derivatives of malathion constitute the major portion of malathion metabolites strongly suggests the presence of powerful carboxylesterases in these microorganisms. Some of the variants of *T. viride* showed high desmethylation activities, which suggests another degradation pathway in these organisms. The result of the metabolite analysis indicated that the conversion of malathion to the more toxic analog, malaoxon, did not take place in these microbial preparations; this suggests that these microorganisms lack proper oxidative systems.

Trichoderma viride is a very common species of fungus in the soil, as indeed are many species of the genus *Pseudomonas*, and their presence should be of great interest from the viewpoint of eliminating some insecticides. It is equally conceivable that the toxic properties of a compound might be extended by altering the populations of these microorganisms in the soil.

F. MATSUMURA
G. M. BOUSH
Department of Entomology, University of Wisconsin, Madison

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Dominant Hemispherectomy: Preliminary Report on Neuropsychological Sequelae

Abstract. *The first reported case of continuing survival 6 months after left hemispherectomy for glioma in a right-handed adult shows diminishing psychological impairment. Different degrees of initial impairment and in subsequent recovery of propositional speech, verbal comprehension, reading, writing, and other functions indicate quantitative rather than qualitative differences in adult left- and right-hemispheric functions.*

We describe here the first reported case of an adult (E.C., a 47-year-old male who was right-handed and right-eyed) who is continuing to improve in many functions more than 7 months after removal of the entire left cerebral hemisphere because of glioma. The initial symptoms of tumor and the effects of hemispherectomy confirmed that the left hemisphere was "dominant" for language. In this preliminary report we summarize salient changes during the first 7 months after hemispherectomy.

Beginning in November 1964, E.C. experienced increasingly frequent attacks of speechlessness and seizures in the right arm and right face. Neuropsychologic studies showed right-sided manual and ocular dominance, consistent with a family history of right-handedness (both parents, two siblings, and his two children). A tumor removed from the left sensory-motor area on 31 March 1965 was identified as a glioblastoma multiforme. Subsequent progressive right-sided weakness indicated recurrence of the tumor and a left hemispherectomy was performed by one of us (C.W.B.) on 7 December 1965. (In summary, the surgical report stated that the corpus callosum was split lateral to the anterior cerebral artery, all branches of the artery being coagulated and divided. After cutting through the thalamus posteriorly and the basal ganglia anteriorly, the entire hemisphere was removed in one piece.)

Immediately following hemispherectomy, the patient had a right hemiplegia, right hemianopsia, and severe aphasia. Ability to follow simple verbal commands indicated normal hearing and some comprehension of speech. Tests on 31 May 1966 showed normal hearing at 250 to 2000 cy/sec in each ear and a moderate bilateral loss at 4000 cy/sec in responses to pure-tone stimuli delivered through a hand-held receiver.

The patient spontaneously articulated words and short phrases fairly well immediately after the operation. However, he could not repeat single words on command or communicate in "propositional" speech until February 1966. Although he is still unable to speak voluntarily most of the time, occasional propositional speech continues to increase, along with ability to repeat successfully longer sentences on command in fewer trials. In May 1966 the patient was asked questions to test his comprehension. His replies to questions about the weather and an appointment showed that he understood what was asked, and he gave the correct number of years when asked how long he had lived in his house. In the fifth postoperative month, E.C. showed sudden recall of whole familiar songs, and he now sings with little hesitation and with few errors in articulation.

Learning to print single words with his left hand required several practice sessions in occupational therapy, but, in May 1966, the patient was able to say and print correctly the word "cow" when he was shown a picture and asked to write the name of the object. Writing, however, has shown little subsequent improvement. Improving comprehension of spoken words was reflected in E.C.'s increasing scores in the Peabody picture vocabulary test (PPVT). On 25 January 1966, he slowly but correctly selected four of the first six items from six pages, each with four pictures to choose from, before indicating he was tired; on 3 June he correctly selected 85 of 112 items. The marked improvement in PPVT scores shows an increasing attention span and capacity for prolonged testing, as well as increasing verbal comprehension which was evident in conversation and in performances on other psychological tests.

On 23 May 1966 five colored pens (red, blue, green, yellow, and black) were placed before E.C. and he was asked to pick up the yellow pen. At first he selected the red one at his extreme left, but when it was carefully explained that this was a test to see if

he could recognize colors and that he was to pick up only the pen having the specified color, he proceeded to select correctly the randomly named colors on all nine remaining trials. The test was repeated with printed instructions instead of spoken ones, and he was correct in all five trials on this test. Color blindness was ruled out by correction performances on the Ishahara test.

Reexaminations with the WAIS performance subtests were supplemented with other tests. Comparison of E.C.'s scores before and 6 months after hemispherectomy indicate initial impairment and subsequent recovery of preoperative levels in these subtests (performance IQ's of 108 and 104, prorated, in May and June 1966 compared with 100 before excision biopsy in February 1965).

The patient's memory for visual motor patterns was tested by the Knox cubes in January 1966; correct responses were obtained to the first three patterns on the first trial and to the fourth pattern on the second trial, but there was failure on all three trials for the fifth pattern. On 3 June, however, he correctly responded to all five patterns on the first trial. Using his left hand, E.C. made scores of 12½ years on 25 May, 1966 and 15 years on 3 June on the Porteus Maze, a test designed to measure "foresight" and nonverbal intelligence.

Arithmetic reasoning improved markedly in the first 6-month postoperative period. On 25 January 1966 E.C. picked up correctly from one to five blocks on command, but he could not select correct answers for simple problems in addition from four possible choices. On 27 May he was able to select correct answers for all ten problems of addition (sums of three to five numbers of one and two digits) from the four choices. On 31 May 1966 he also selected correct answers for all three problems in simple multiplication, all three in subtraction, and two of three in division. Concrete calculation ability was tested on 2 June by asking the patient for specific sums of money to be assembled from coins and a single dollar placed before him; he assembled correctly thirteen of the eighteen amounts requested.

E.C. could not identify objects that were placed in his right hand, but he made no errors in selecting fourteen different objects (eraser, spoon, key, nickel pipe reamer, typewriter eraser, and matchbook) placed in his left hand. Left-handed dexterity, tested on 3 June with the Purdue pegboard, was almost identical with normal performances before hemispherectomy. The ability to follow verbal commands that required other purposeful movements of the left hand showed that there was no evidence of "sympathetic dyspraxia."

Marked variability in attention span and in susceptibility to fatigue and distractability, reported following right hemispherectomy in similar cases, was also observed in E.C. shortly after hemispherectomy but gradually decreased. However, "loss of personality values," reported after right hemispherectomy, was not observed. The affective reactions and general behavior that were observed before and after hemispherectomy were appropriate, and they were consistent with the report from the patient's wife that there was no noticeable change in emotional responses or in a basically well-balanced personality.

The patient E.C. can now tell time; he moves about independently in his wheel chair, keeps appointments on other floors in the hospital (requiring use of the automatic elevator) without being reminded, and has been going home for weekend visits since 26 March 1966. Libidinal drives were reported normal. Most important, perhaps, he demonstrates a capacity to enjoy and participate in human relationships despite his marked disabilities.

Because the range of individual variability in hemispheric functions is unknown, it is impossible to say how representative these findings are. Zangwill observed that, like handedness, "cerebral dominance is in all probability a graded characteristic, varying in scope and completeness from individual to individual" (*1*, p. 27). Benton reviewed the problems of defining cerebral "dominance" and the various views on the roles of the two human hemispheres in different functions based on studies of patients with focal lesions (*2*).

The continuing improvement in psychological functions described above, following left hemispherectomy, is consistent with the independent clinical findings and the electroencephalographic studies that show normal tracings over the remaining hemisphere after the fourth postoperative month. There have been fewer than 50 reported hemispherectomies for glioma since Dandy (*3*) and over 300 right or left hemispherectomies for infantile hemiplegia since Krynauw (*4*), but the findings cannot be reviewed here. Continuing survival with recovery or development of cerebral functions following left hemispherectomy for infantile hemiplegia or glioma in children reflects the "functional plasticity" of the young brain. "Transfer" of language to the "nondominant" hemisphere is described as the rule up to the age of 15 (*5*).

Reports of approximately 36 right and only two left hemispherectomies for tumors in adults thus reflect widespread views on the unique role of the adult "dominant" hemisphere and the belief that once a function has been "established" in either the right or left cerebral cortex, it cannot be "transferred" (*6*). Nonetheless, most adults who survived right hemispherectomy recovered sufficiently in left-sided motor functions to walk unaided, and some developed useful movements of the left arm.

The continuing recovery of functions in the single case described here is consistent with observations in the only other similar cases that have been reported—a 43-year-old woman (*7*) and a 39-year-old man (*8*) who died 17 and 113 days, respectively, after left hemispherectomy for glioma. Although early postoperative death precluded further studies of recovery of language functions in the two latter cases, speech and verbal comprehension were present immediately after left hemispherectomy in all three cases.

Since language functions are not destroyed, and since speaking, reading, writing, and understanding language show continuing improvement in E.C. after left hemispherectomy, the right hemisphere apparently contributes to all these functions, although in varying proportions (for example, receptive language functions were initially less impaired and have shown greater recovery than expressive language).

Thus hemispheric functions would seem to differ quantitatively rather than qualitatively. Although postoperative complications (including thrombophlebitis and anemia) may be a factor in accounting for the absence of partial recovery of right-sided motor functions in E.C. up to this time, bilateral representation of these functions, first suggested by Jackson (*9*), is indicated by the patient's ability to move the fingers on his right hand on command. These findings are also consistent with other studies cited by Luria (*10*) which indiate "that both hemispheres participate jointly in the performance of complex

mental functions (including speech)" (*10*, pp. 87–88).

The ability to recall and sing familiar songs suggests that the right hemisphere plays an equal or greater role in musical memory and in the neuromotor processes of singing. The increasing comprehension of spoken words and use of propositional speech were also reported in the only two similar cases of left hemispherectomy for glioma and one for seizures of late onset in adults (*11*). The consistent findings indicate that, in addition to comprehension of speech, the adult right hemisphere alone is capable of more than the automatic primitive utterances first described by Jackson.

The ability to discriminate color, solve abstract and concrete mathematical problems, engage in purposeful movements with the left hand, and to perform at a nearly normal level in nonlanguage tests of "higher" mental functions indicates either that these functions are not exclusively or predominantly "localized" in the adult dominant hemisphere, or that, following removal of this hemisphere, the right hemisphere has the capacity to amplify previously smaller contributions to these functions. Although a spastic right hemiplegia and right hemianopsia have shown no improvement during the first 6 months following surgery, this case indicates that adult man may survive the removal of a dominant hemisphere that has matured normally until the development of an otherwise incurable and inevitably fatal glioma.

AARON SMITH
Nebraska Psychiatric Institute,
602 South 44th Avenue,
Omaha, Nebraska 68105
C. W. BURKLUND
Veterans Administration
Hospital, Omaha

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"Dream Deprivation": Effects on Dream Content

Abstract. *Dream content elicited following the selective deprivation of rapid-eye-movement sleep was intensified compared to that elicited under nondeprivation conditions. This effect was observed both for repressers and for sensitizers, but was significant only for repressers. On nondeprivation nights, the dream periods of sensitizers were shorter and their dreams more intense than those of repressers.*

The finding (*1*) that dreaming is associated with a random, low-voltage electroencephalogram (EEG) pattern (ascending EEG stage 1) in conjunction with intermittent bursts of conjugate rapid eye movements (REMs), and that this pattern recurs four or five times during a typical night's sleep (*2*), has prompted renewed interest in the possible functional significance of dreaming. Experimental attempts to assess the importance of dreaming for human subjects have employed a method of dream deprivation, in which subjects are awakened at the onset of each episode of ascending stage 1 sleep and are thus prevented from experiencing the organismic state in which dreaming occurs. Early studies employing this method found progressively decreasing latencies to the recurrence of dream periods on deprivation nights, a compensatory increase in this stage of sleep on uninterrupted recovery nights following the deprivation treatment, and increased anxiety, irritability, and appetite during the deprivation period. These results were interpreted as a "buildup of a pressure to dream" (*3*).

More recently, however, failure to observe the reported behavioral changes with human subjects (*4, 5*) and demonstration of the sleep-cycle effects of dream deprivation in intact and chronic pontile cats (*6*) have led to the interpretation that the supposed effects of the deprivation of a psychological experience are actually the effects of the deprivation of a physiological stage of sleep with some unknown biological significance (*7*). While it may ultimately prove impossible to distinguish the effects of the deprivation of this stage of sleep from the effects of dream deprivation, the present study shows that the nature of dream content, as well as of the sleep cycle, is affected by the selective deprivation of ascending EEG stage 1. In particular, the content of a dream elicited following such deprivation is intensified as a result of this manipulation.

Each of twenty male subjects slept in quiet, darkened laboratory rooms for two nonconsecutive nights. Ten of the subjects were among low scorers (repressers, those who react to threatening stimuli with avoidance defenses such as denial) and ten among high scorers (sensitizers, those who react to threatening stimuli with approach defenses such as intellectualization) on Byrne's Repression-Sensitization Scale (*8*) of the Minnesota Multiphasic Personality Inventory (MMPI). The subjects selected represented the top and bottom fifth of the distribution of test scores of male volunteers from an introductory psychology class.

Continuous EEG and electro-oculogram (EOG) recordings were taken during the night. Electromyogram recordings were also taken from the submental region, as a sharp drop in tonus of neck and chin muscles generally precedes the onset of ascending EEG stage 1 by a minute or so and can be used as a signal of such onset (*5, 9*). Ascending EEG stage 1 onset was determined by the appearance of a random, low-voltage EEG pattern accompanied by rapid eye movements, or a sudden drop in submental muscle tonus, or both. On experimental nights, the first four REM periods were interrupted at the first sign of ascending stage 1 onset. On control nights, four awakenings were made during non-REM sleep so as not to interfere with the occurrence of REM sleep. The fifth REM period on experimental nights and the third one on control nights were allowed to proceed for 5 minutes, after which awakenings were made for retrieval of dream content. Half of the repressers and half of the sensitizers, selected at random, were run in the order experimental-control, while the remaining subjects were run in the reverse order.

The elimination of REM sleep and the progressive shortening of the pe-