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ERROR RECOGNITION AND UTILIZATION PRODUCED BY INJURY TO THE FRONTAL CORTEX IN MAN

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Abstract—In an earlier study, a patient with frontal lobe damage had been observed and had been noted to suffer from “an equivocal disturbance of error evaluation.” The terms error “evaluation” and “utilization” were employed synonymously.

Neuropsychological examination of the patient reported here clarifies this “equivocal disturbance”: it became clear that error recognition remains intact although error utilization is disturbed. Consequently the nature of the frontal lobe syndrome is re-evaluated.

INTRODUCTION

ON AN earlier occasion LURIA *et al.* [1] presented a report of an experimental analysis performed on a patient with a frontal lobe tumor. The authors concluded that the patient suffered from the following syndrome:

(1) An inability to carry out compounded or “symbolic” instructions whether these were given verbally or presented as a visual model. These incapacities did not depend on any difficulty in apprehending the instructions *per se*.

(2) A disturbance of the vascular and skin reactive components of the orienting reaction.

(3) An equivocal disturbance of error evaluation.

The present report is made because we had the opportunity to examine a patient with frontal lobe damage and to test these findings. Our observations confirmed many of the earlier findings and clarified some remaining problems regarding error evaluation.

GENERAL OBSERVATIONS AND COURSE OF THE PATIENT'S ILLNESS

The patient, I.S., a 69 year old housewife entered the Stanford Medical Clinic in October, 1969 where a diagnosis was made of Hodgkin's disease with metastasis to the left frontal lobe of the brain. Her presenting symptoms were confusion, a progressive expressive aphasia and a right hemiparesis.

The patient had been in good health until two years before admission when she began to experience easy fatigability, night sweats, gaseous distension and constipation. At about this time she noted a mass in the left lower quadrant of her abdomen which eventually led to an exploratory laparotomy. The mass was found to be attached to the uterus and to extend up to the level of the umbilicus. A biopsy was taken and a diagnosis of Hodgkin's disease was made. Treatment with radiotherapy was instituted and proved effective in controlling the illness until the current episode.

On September 18, 1969 the patient's daughter found the patient slightly confused and two days later an inability to talk developed. A physician was called and he noted that a right hemiparesis was also present. An automatic and spontaneous recession of symptoms occurred but on October 18, 1969 they recurred and the patient was sent to the Stanford Clinic. Examination confirmed what had already been noted—however, in addition to the hyperreflexia accompanying the right hemiparesis, a slight hyperreflexia was also noted on the left. Shortly a right homonymous hemianopsia also developed. There were, however, no signs of increased intracranial pressure.

Electroencephalography showed slowing of the brain wave record obtained from the left anterior frontal lead with occasional epileptic type of activity. A brain scan also pointed to a pathological process in the left frontal region. An arteriogram revealed a striking mass at the left frontal pole shifting the location of anterior cerebral artery and vein.

On December 16, 1969 a left frontal osteoplastic craniotomy was performed by Dr. John W. Hanbery. The dura was found to be abnormally hemorrhagic and infiltrated along its under surface with a white, firm tumor which at one point, about 2 cm behind the frontal pole, extended into the left-frontal lobe as an infiltrating mass. Further exploration revealed other smaller fronds of infiltrating tumor. A biopsy was taken and a clear diagnosis of Hodgkin's was made. A part of the tumor was removed en bloc, then about 5 cm of left frontal brain tissue was resected. Midline tissue and Broca's area were left untouched and the anterior cerebral artery was not damaged; however, all of the tumor could not be excised because of its extent beyond the reach of the craniotomy.

After surgery a temporary left rhinorrhea developed but otherwise postoperative recovery was uneventful. Radiotherapy to the head was begun two weeks later and we examined the patient another two weeks thereafter.

THE NEUROPSYCHOLOGICAL EXAMINATION

At this time many of the obvious neurological difficulties had subsided. There was no longer any trace of hemianopsia and the hemiparesis had receded, although some slight cogwheel rigidity was demonstrable in both hands and feet and an abnormal Gonda sign could be obtained on the left despite the absence of pathological Babinski or Hoffman's signs. The patient was somewhat disoriented in time and place: We examined her in mid-January but she thought it was before Christmas. She knew she was in the Stanford Hospital but was confused about where objects were located.

The results of our initial formal examination, pursued according to the format described by LURIA, PRIBRAM and HOMSKAYA [1], were clearly indicative of frontal disturbance. The patient exhibited the usual difficulties predicted by use of this format. Asked to make a square, the patient scrawled an "O". The most striking aspect of her behavior was that she immediately exclaimed as she did this that it was not a square—nevertheless went over and over her "O" laboriously, never managing to give corners to the figure. This pattern of behavior was repeated many times and in different forms. For instance, on another occasion the letter "A" was written in response to almost any command. When asked to draw a square the patient began drawing an A, simultaneously exclaiming "that's not a square—I guess I'll draw you an A." When the command to draw a square was repeated another A was produced while the patient explained that she "couldn't draw a square," so she "would draw another A." However, when a square was then drawn for her as a visual model and she was asked to make a copy, she quickly and accurately made a square.

Clearly the patient indicated to us that she knew when she was making an error. We therefore confronted her with a test in which one of us carried out the commands of the other, sometimes correctly and sometimes erroneously. The patient usually had no difficulty in spotting our errors. This was true even when they were embedded in rather complex serial performances.

On the other hand, when the patient was asked to perform the same serial tasks herself she had difficulty. On occasion she was able to spot her errors specifically; more often she would try to justify her erroneous performance by claiming confusion or inability to maintain attention. Often she would wring her hands and engage in conversation irrelevant to the task, usually expressing concern of some sort.

In other respects the patient was in many ways similar to the earlier one reported by LURIA *et al.* [1] although at the time of examination not nearly as severely affected. Verbal behavior was intact though the patient tended to use the simplest and most frequently encountered speech forms. She had no difficulty in executing verbal sequences but, as noted above, did have difficulty when instructions were given verbally but were to be executed non-verbally. Compound instructions could, however, often, though not always, be carried out when isomorphism was maintained. Our patient also had less difficulty with symbolic instructions than the earlier one; nonetheless she quickly tired and became confused during this part of the examination.

DISCUSSION

Our results clarify considerably some difficulties in interpretation encountered by LURIA *et al.* [1] in the earlier study. There can be no question that our patient could recognize the errors made by others and those made by herself as well. Our patient had considerably less general confusion than the earlier one so her replies were more consistent and clearcut. This clarity made it obvious that despite the intact error recognition mechanism, the patient did not utilize this knowledge to control her own behavior. In the earlier study the terms error "evaluation" and "utilization" were employed synonymously. Our patient makes it

clear that if by evaluation is meant recognition, this synonymy is faulty. Evaluation and utilization must be distinguished and indeed in economic theory "value" and "utility" have been given different specific definitions. Further, in analyzing another set of experimental data, one of us (KHP) indicated that the evaluative process depends upon the functions of the posterior parts of the brain while "utility" became disturbed when frontolimbic lesions were made in subhuman primates [2, 3]. The dissociation rests therefore on firm behavioral and neurological evidence.

The earlier study noted that "error utilization" is possibly related to "ease of disequilibrium" as indicated by disturbed vascular and galvanic skin components of the orienting reaction. This view is based upon the assumption that feedback from errors is no longer registered by the patient. However, the results obtained in the present study indicate that errors are recognized and registered in awareness and to some extent in memory. Thus the relevance of the disturbance of the orienting reaction needs to be re-evaluated: in the light of the earlier analysis, the remaining alternatives are that disequilibrium is related to the patient's inability to carry out compounded and/or "symbolic" instructions.

The execution of both compound and symbolic instructions involves a transfer process: In the case of compounding a context must be maintained over the series of acts, thereby necessitating that the initial verbal instruction be applied anew to each component of the task. In the symbolic condition there is a similar necessity for applying on one plane, a higher level context that classifies acts at another. Thus these two procedures are in effect in man, equivalent to the less complex delayed alternation and delayed response problems (respectively) which have been classically shown to be deficient in subhuman primates after frontal lobe resection [4].

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REFERENCES

1. LURIA, A. R., PRIBRAM, K. M. and HOMSKAYA, E. D. An experimental analysis of the behavioral disturbance produced by a left frontal arachnoidal endothelioma (meningioma). *Neuropsychologia* **2**, 257-280, 1964.
2. PRIBRAM, K. H. On the neurology of values. *XVth International Congress of Psychology*, Brussels, July-August, 1957 (Abst.).
3. PRIBRAM, K. H. The intrinsic systems of the forebrain. In *Handbook of Physiology, Neurophysiology II*, J. FIELD, H. W. MAGOUN and V. E. HALL (Editors), pp. 1323-1344. American Physiological Society, Washington, 1960.
4. JACOBSEN, C. F., WOLFE, J. B. and JACKSON, J. A. An experimental analysis of the functions of the frontal association areas in primates. *J. nerv. ment. Dis.* **82**, 1-14, 1935.

Résumé—Dans une étude antérieure, on a présenté l'observation d'un sujet avec atteinte frontale; il avait été noté qu'il présentait "un trouble de l'évaluation des erreurs", en fait difficile à décrire. Les termes "évaluation" et "utilisation" des erreurs étaient employés comme synonymes.

L'examen neuropsychologique du malade présenté ici clarifie ce qu'il y avait d'incertain dans l'interprétation de ce trouble. En effet, il apparaît clairement que la connaissance de l'erreur restait intacte, bien que l'utilisation de l'erreur fut troublée. En conséquence, la nature du syndrome frontal est réévaluée.

Zusammenfassung—In einer früheren Studie wurde ein Patient mit einem Frontalhirnschaden geschildert, bei dem eine zweifelhafte Störung in Form einer Fehleinschätzung vorlag. Die Ausdrücke Fehleinschätzung und Fehlbewertung wurden synonym gebraucht. Die neuropsychologische Untersuchung dieses Patienten hat nun die zweifelhafte Störung aufgeklärt. Es stellte sich heraus, daß keine fehlerhafte Erfassung bestand, während die Bewertung beeinträchtigt war. Die Konsequenzen dieses Symptoms für die Frontalhirnsymptomatik wurden ausgewertet.