AUTISM: A DEFICIENCY IN CONTEXT-DEPENDENT PROCESSES?

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This will be an informal communication giving some of my thoughts on autism. These thoughts are generated by similarities between the autistic syndrome and the effects of certain types of brain surgery. The similarities center on the fact that intellectual and emotional capabilities appear to become dissociated from one another. I will make a case here for the view that this dissociation is apparent only, that in fact a disturbance occurs that is basic to both interpersonal emotion and specific facets of the intellectual problem-solving process. The autistic child presents a paradox. He is not generally retarded in problem-solving ability as is the mongoloid, for instance. Nor does he display specific disorders that can be readily correlated with known neurological damage as in the cerebral palsied, spastic child. The autistic child is an enigma to his parents, his physician and his teachers.

My own encounter with paradox came while in the practice of neurosurgery. It was during the hey-day of psychosurgery when frontal lobotomy was an accepted routine procedure. Psychiatrists would certify a patient for surgery, the surgeon would, frequently sight-unseen, deploy the leukotome: a long dull knife blade, an egg beater or an ice pick, depending on his preference. Often surgeon and patient did not become acquainted until after the operation when dressings had to be changed, etc..

I wanted no part of such doings. My surgical training had insisted that I make my own diagnoses before cutting and that the most basic principle of medical care was "prime non nocere"--"first of all do not injure". But how did one go about diagnosing emotional disturbance and how did one evaluate whether one had injured a patient's mental makeup?

These questions led me first to devise my own diagnostic procedures and tests of perceptual and motor skills and

problem-solving capacities. I quickly found limitations to these homemade procedures and tests (e.g. many of the nurses I used as control subjects did as poorly as lobotomized patients) and so turned to professional clinical and experimental psychologists for help. Despite this, I found the problem of evaluating the lobotomy procedure terribly complex and decided that first some basic research on non-human primates was needed in order to properly formulate the questions that must be asked.

Meanwhile, others were exploring the effects of surgery on man's frontal lobes. The most impressive research was that of the Columbia-Greystone group directed by the neuroanatomist Fred Mettler (Mettler, 1949). Lawrence Pool performed selective partial ablations of the frontal cortex of patients who were tested and observed by a team of specialists headed by Robert Heath, a psychiatrist. This research, as did most others of its sort, showed minimal effects of the psychosurgical procedure on tested performances, but dramatic changes in "personality," "interpersonal relationships" and other such difficult to specify clinical entities.

My experience with non-human primates, chimpanzees and monkeys, was just the contrary, and thus the paradox. Though some specific changes in emotionality such as the shortening of the duration of a reaction to frustration were demonstrable after frontal surgery; the impressive effect of the procedure was on problem-solving ability. Not all sorts of problem solution were impaired--sensory discriminations, for instance, remained intact. The difficulty of the frontally lesioned primate was manifest on problems such as delayed response and delayed alternation in which the cue to proper performance is no longer present when a choice has to be made. Choices in such problems are dependent on recall of a cue that was presented or a behavioral outcome that took place some seconds or minutes before the opportunity for choice is given. Since frontally damaged non-human primates failed this task, the interpretation was made that the frontal lobes were critically involved in recall, in short-term memory.

In short, paradoxically, frontal surgery in man affected personality, not memory in any obvious fashion; in non-human primates such surgery altered short-term memory, not personality in any obvious fashion.

The paradox was compounded some years later when just the reverse situation developed as a result of surgical invasion of the temporal lobe of man's brain, resections of the limbic structures (amygdala and hippocampus) which form the medial portions of this lobe. Now severe deficits in man's memory were unaccompanied by any obvious changes in personality. In monkey, by contrast, after resection of limbic structures problem-solving impairments were initially extremely difficult to demonstrate while changes in temperament, tractability, sexuality, etc. were profound and dramatic.

The easy explanation for the human vs. non-human discrepancies has recourse to the simple fact that man is, of course, different from his non-human primate relatives. But this explanation is no explanation but only a restatement of the findings. What the scientist is after is some basic conceptualization that can account for the double paradox. To this end, tests have been refined and better tailored to the organism being tested. Evaluations of changes in temperament and personality have been quantified to provide more sensitive indices of change. Though the story is still incomplete, twenty-five years of research has produced a yield. Here are some of the highlights in results and my interpretation of them:

A. Differentiating Frontal and Limbic Structures from the Rest of the Primate Forebrain:

1. The problem-solving tasks impaired by frontal damage are also impaired (though not all tests show damage to all structures) by limbic damage, but never by damage to the remainder of the brain cortex (Pribram, 1969a).

2. The converse also holds. The type of discrimination task impaired with damage to cortex outside the fronto-limbic brain remains intact following frontolimbic damage.

3. There is good anatomical and neurophysiological evidence that links frontal cortex to limbic structures (Pribram, 1958; Nauta, 1964).

4. When non-verbal tests are used a graded series of impairments in the delayed alternation type of problem-solving can be demonstrated from monkey, through chimpanzee to man (Pribram, et al., 1964; Poppen et al., 1956).

These experimental results suggest that the primate forebrain can usefully be divided into a frontolimbic core and an outer shell. It is as if we had two separate brains, one inside the other, each with its own function.

B. Specifying the Difference in Function Between Frontolimbic Core and Outer Cortical Shell:

1. As noted, the impairment following frontolimbic damage involves short-term memory, that following damage to the outer shell involves perceptual and motor discriminative skills (Pribram, 1969b).

2. The defect in short-term memory does not result primarily from a more rapid decay in memory trace, but from a failure to register what needs to be remembered (Pribram and Tubbs, 1967).

3. This impairment of registration shows up when the demanded behavior depends on changing conditions. The changes act as distractors interfering with the memory process (Grueninger & Pribram, 1969; Pribram, 1969a). Try yourself to remember a telephone number just looked up when an interruption intervenes before you can make your call. Even in the intact human recall is severly limited.

The results of this set of studies can be conceptualized as follows: We have two modes of operating in our environment--one mode uses signs and the other uses symbols. Signs are derived from consistencies in a situation: an apple is an apple whether on a tree, in a fruit basket or rotting on

the ground. Symbols on the other hand, have different meanings in different situations. Their meaning derives in each circumstance from what the organism brings to that circumstance, his current state, the history of his reactions to similar circumstances. Stated more formally, signs are context-free attributions signifying the constant aspects of the environment; symbols are context-dependent constructions symbolizing the organism's sensitivity to changes in the environment. The brain's outer shell is involved in making signs; its frontolimbic core in making symbols.

C. Is it then possible for Non-Human Primates to Make Signs and Symbols?

1. The Gardners (1969) at the University of Nevada have trained a young chimpanzee named Washoe to communicate by means of a hand signalling system used by the deaf and dumb--American Sign Language. Washoe has mastered 150 such signs, invented a few of her own, and can string signs together in a haphazard order; e.g. you-pet-me; pet-you-me; me-you-pet, etc.. Washoe is as yet capable of none but the most rudimentary communication when meaning is dependent on the order in which signs have to be made. Nor is her vocabulary comparable to that of a deaf and dumb human child of the same age. Nonetheless, the Gardners' and Washoe's achievement shows beyond doubt that chimpanzees can communicate by means of signs.

2. David Premack (1970) of the University of California at Santa Barbara has taught a young chimpanzee, Sarah, to communicate by means of symbols. Premack developed a hierarchy of arbitrary tokens which take meaning from the situation in which they appear--much as in one form of the delayed response task and a poker-chip chimpomat which was developed from it during the 1930's. Sarah has also a vocabulary size of around 150 and has shown evidence of communicating when meaning is derived from order. Again, by comparison to a human child, Sarah's accomplishments are rudimentary, but nonetheless striking.

These experimental results, just like the earlier ones on the effects of brain damage on problem-solving, indicate a continuum of primate problem-solving ability and brain involvement in this ability. The paradoxical effects of brain damage on memory and emotion ought not therefore to be explained away by taking refuge in the fact that monkeys, chimpanzees and man are grossly different.

So, how can the paradoxical effects of brain damage on memory and emotion be explained? They cannot be completely, at this time. But this much can be suggested. Both short-term memory and interpersonal emotion are context-sensitive, symbolic processes. The way in which a particular situation becomes symbolized is different for man and non-human primate, in part because man has so much greater linguistic facility. At present, there is little evidence that either Washoe or Sarah can make propositional utterances upon which human language is based. In non-verbal communication, the non-human primate also shows limitations in the complexity of the context to which he can react. These may well be the reasons why monkeys, chimpanzees and humans react differently when context-sensitive behavior such as memory recall and interpersonal emotion are manifest.

In summary, I believe that the paradoxical effects of damage to the frontolimbic core of the brain result from the fact that these core-brain systems are involved in context-sensitive behaviors. Independence from context leads to the identification of consistent environmental attributes which are more or less the same for all individuals irrespective of genus. When, however, meaning depends on context, the organism's particular memory and emotional makeup become critical.

So now to return finally to autism. I want to propose the hypothesis that the autistic child is deficient in context-sensitive processes, and that this deficiency should declare itself both in problem-solving and in interpersonal emotional reactions. The hypothesis is readily tested and if evidence in support accumulates, one would next wonder if for one reason or another the frontolimbic corebrain of these children has become damaged and if the damaging agent can be found and eradicated. In the meanwhile, remedial

steps can be taken. Sensitivity to context can be enhanced through making the child aware of the context-dependency of aspects of situations and training appropriate response mechanisms. Further, if parents, physicians and teachers know with what specific difficulty the autistic child is coping, allowances can be made, the child becomes understood, and thus less of an exasperating paradox. This charts my path toward hope. Does it ring a responsive chord in you?

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References

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Grueninger, W. and Pribram, K.H. The Effects of Spatial and Nonspatial Distractors on Performance Latency of Monkeys with Frontal Lesions. J. Comp. Physiol. Psychol., 1969, 68, 203-209.

Mettler, F.A. (ed.) Selective Partial Ablation of the Frontal Cortex: A Correlative Study of Its Effects on Human Psychotic Subjects. (Columbia-Greystone Associates). New York, Paul B. Hoeber, Inc., 1949.

Nauta, J.H. Some Efferent Connections of the Prefrontal Cortex in the Monkey. In Warren, J.M. and Akert, K. The Frontal Granular Cortex and Behavior. New York, McGraw Hill, 1964, 397-409.

Poppen, R., Pribram, K.H. and Robinson, R.S. The Effects of Frontal Lobotomy in Man on Performance of a Multiple Choice Task. Exp. Neurol., 1965, 11, 217-229.

Premack, D. The Education of Sarah: A Chimp Learns the Language. Psychology Today, 1970, 4, 55-58.

Pribram, K.H. Comparative Neurology and the Evolution of Behavior. In Simpson, G.G. (ed.) Evolution and Behavior. New Haven, Yale University Press, 1958, 140-164.

Pribram, K.H. The Amnestic Syndromes: Disturbances in Coding: In Talland, G.A. and Waugh, N.C. (eds.) Psychopathology of Memory. New York, Academic Press, 1969a, 127-157.

Pribram, K.H. The Primate Frontal Cortex. In Pribram, K.H. (ed.) Inhibition in Neuropsychology (a symposium). Neuropsychologia, 1969b, 7, 259-266.

Pribram, K.H., Ahumada, A., Hartog, J. and Roos, L. A Progress Report on the Neurological Processes Disturbed by Frontal Lesions in Primates. In Warren, J.M. and Akert, K. (eds.) The Frontal Granular Cortex and Behavior. New York, McGraw Hill, 1964, 28-55.

Pribram, K.H. and Tubbs, W.E. Short-term Memory, Parsing and the Primate Frontal Cortex. Science, 1967, 156, 1765-1767.

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