# Letters

## On Supplementing Human Faculties

It was hardly to have been predicted that when a human being is completely isolated from external stimuli, as was the case in an experiment conducted by the Office of Naval Research in 1956 [discussed at the Interdisciplinary Conference on Self-Organizing Systems, Chicago, May 1959], he loses his sense of orientation and cannot change a set idea in his mind. Rather one would have assumed that he could continue to meditate on past experiences, much as if he were sitting alone in the dark of a warm, silent cave. The question occurs: Can a person be thrown into a higher level of consciousness by supplementation of his faculties? Certainly the effect of faculty supplementation can be observed in ourselves to a mild degree when we are listening to music or sitting in a Cinerama theater. What would happen if a more complete coupling were achieved between man and an artificial world, or between a person and more intense stimulation from his natural world?

This leads to another question: What faculties would have to be added to a monkey to make him react like a human being? For one thing, a monkey lacks the ability to formulate and recognize symbols. But he can learn a great deal. Conceivably, an electronic aid to symbol recognition or formulation might be provided for one of our simian friends, and he could be conditioned to use it, say, to recognize and indicate the letters of the alphabet. How much aid in grammar formulation and word categorization would we have to provide him (by means of a computer, perhaps) before he could begin to talk sensibly to us? Would this aid be less than that required by a computer operating alone?

The crux of the matter is undoubtedly in the coupling between external devices and animals. A device has to be more perfectly woven into our nervous system before we can begin to tap it as we naturally tap our other faculties. Also, some control, perhaps even a random control, must be provided, because if the extrasensing devices were not controllable they might assume the upper hand. Of course, in a movie we can shut our eyes, but more control would be necessary with extrasensing devices. If an electronic memory could be coupled into our brain we would have to have some means of scanning it in order to get at arbitrary information.

Before coupling of any higher degree of sophistication than that achieved in a stereophonic Cinerama theater can be achieved, a more thorough understanding must be had of the coding of signals in the brain. Yet, if a person (or a monkey) were conditioned to substitute senses (as, for instance, if supersonic tones in a spectrum of frequencies were transduced into pinpricks along the spine) or coupled to a more perfect form of Cinerama, would he react normally under this greater degree of stimulation?

These speculations may perhaps seem fantastic, but in the light of the results of the Office of Naval Research experiment they must be given serious consideration.

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## Phosphorus and Phytoplankton

In the article "Bound phosphorus and growth of phytoplankton," by Whitford and Phillips [*Science* **129**, 961 (1959)], the implication that phosphorus was not limiting because total phosphorus showed no correlation with phytoplankton pulses does not appear to be valid. Not only do the authors point out that total phosphorus varied with the rainfall but they acknowledge that the phytoplankton populations were low (and presumably, therefore, would require a relatively small amount of phosphorus). Also, and more significant, total phosphorus includes a galaxy of compounds, particulate and soluble, organic and inorganic, of which the only fraction now unequivocally known to be utilizable by algae is soluble orthophosphate. This fraction generally accounts for only about 10 percent of the total phosphorus in lakes, and even in the attempt to correlate this fraction with phytoplankton, the problem is complicated by the fact that certain plankton algae are known to be able to store up phosphate under conditions of plenty and to use this reserve for growth in times of phosphate deficiency. Therefore, any correlations observed between total phosphorus and phytoplankton are likely to be fortuitous, and any lack of correlation is likely to be without significance.

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The criticism by Shapiro of our report is probably justified on the basis of data given. We believe, however, that our conclusions, which were based on data not adequately presented in the article, are valid. We are aware of the number and complexity of phosphorus compounds in natural aquatic habitats. Our analyses of total phosphorus were

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