signs of mental retardation or malnutrition. Their separation from the wolf family caused a profound depression in them and brought them to the brink of death.

The girl who survived for ten years eventually changed her dieting habits and her cycles of activity. She learned to walk on two feet, although she would go back to running on four feet under the stress of urgency. She never learned to speak properly, although she did use a few words. The family of the Anglican missionary who looked after her, as also the other persons who came to know her closely, never felt that she was completely human.

This case—and it is not the only one—shows us that although they were human in their genetic constitution and in their anatomy and physiology, these two girls never managed to fit in with a human context. The behavior that the missionary and his family wanted to change in them, because it was unacceptable in a human context, was completely natural to their wolflike upbringing. In fact, Mowgli, the jungle boy of the forest that Kipling imagined, could never have existed in flesh and blood, for he knew how to talk and behaved like a person from the very first moment he encountered a human environment. We who are flesh-and-blood people are no strangers to the world in which we live and which we bring forth through our living.

On the Razor's Edge

The most popular and current view of the nervous system considers it an instrument whereby the organism gets information from the environment which it then uses to build a *representation* of

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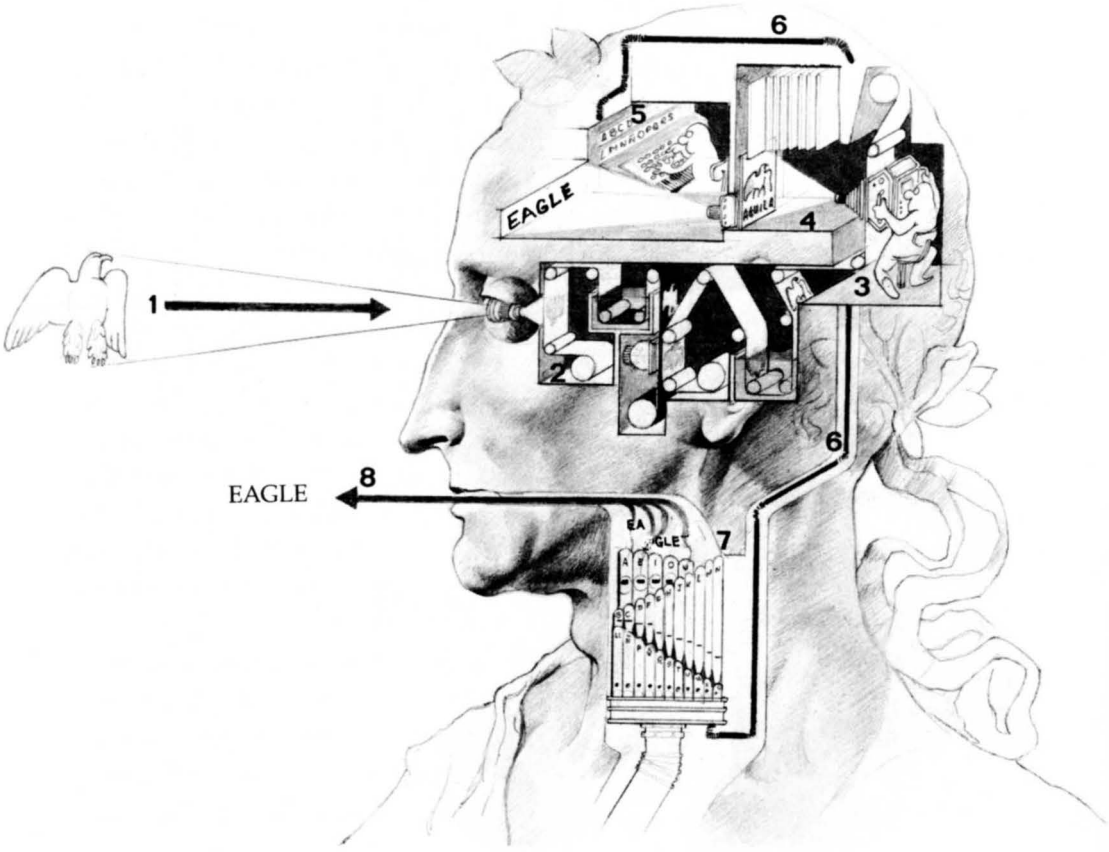
the world that it uses to compute behavior adequate for its survival in the world (Fig. 34). This view requires that the environment imprint in the nervous system the characteristics proper to it and that the nervous system use them to generate behavior, much the same as we use a map to plot a route.

We know, however, that the nervous system as part of an organism operates with structural determination. Therefore, the structure of the environment cannot specify its changes, but can only trigger them. We as observers have access both to the nervous system and to the structure of its environment. We can thus describe the behav-



ior of an organism as though it arose from the operation of its nervous system with representations of the environment or as an expression of some goal-oriented process. These descriptions, however, do not reflect the operation of the nervous system itself. They are good only for the purpose of communication among ourselves as observers. They are inadequate for a scientific explanation.

If we reflect a moment on the examples given earlier, we will realize that our first tendency to describe what happens in each case centers, in one way or another, on the use of some form of

Fig. 34. Caesar according to the representationist metaphor.

observer of organism describes behavior of an organism as though it arose from the operation of its nervous system with representa- tions of the environment or as an expression of some goal-oriented process

the metaphor of "getting information" from the environment represented "within." Our course of reasoning, however, has made it clear that to use this type of metaphor contradicts everything we know about living beings. We are faced with a formidable snag because it seems that the only alternative to a view of the nervous system as operating with representations is to deny the surrounding reality. Indeed, if the nervous system does not operate—and cannot operate—with a representation of the surrounding world, what brings about the extraordinary functional effectiveness of man and animal and their enormous capacity to learn and manipulate the world? If we deny the objectivity of a knowable world, are we not in the chaos of total arbitrariness because everything is possible?

This is like walking on the razor's edge. On one side there is a trap: the impossibility of understanding cognitive phenomena if we assume a world of objects that informs us because there is no mechanism that makes that "information" possible. On the other side, there is another trap: the chaos and arbitrariness of nonobjectivity, where everything seems possible. We must learn to take the middle road, right on the razor's edge (Fig. 35).

In fact, on the one hand there is the trap of assuming that the nervous system operates with representations of the world. And it *is* a trap, because it blinds us to the possibility of realizing how the nervous system functions from moment to moment as a definite system with operational closure. We shall see this in the next chapter.

On the other hand, there is the other trap: denying the surrounding environment on the assumption that the nervous system functions completely in a vacuum, where everything is valid and every-

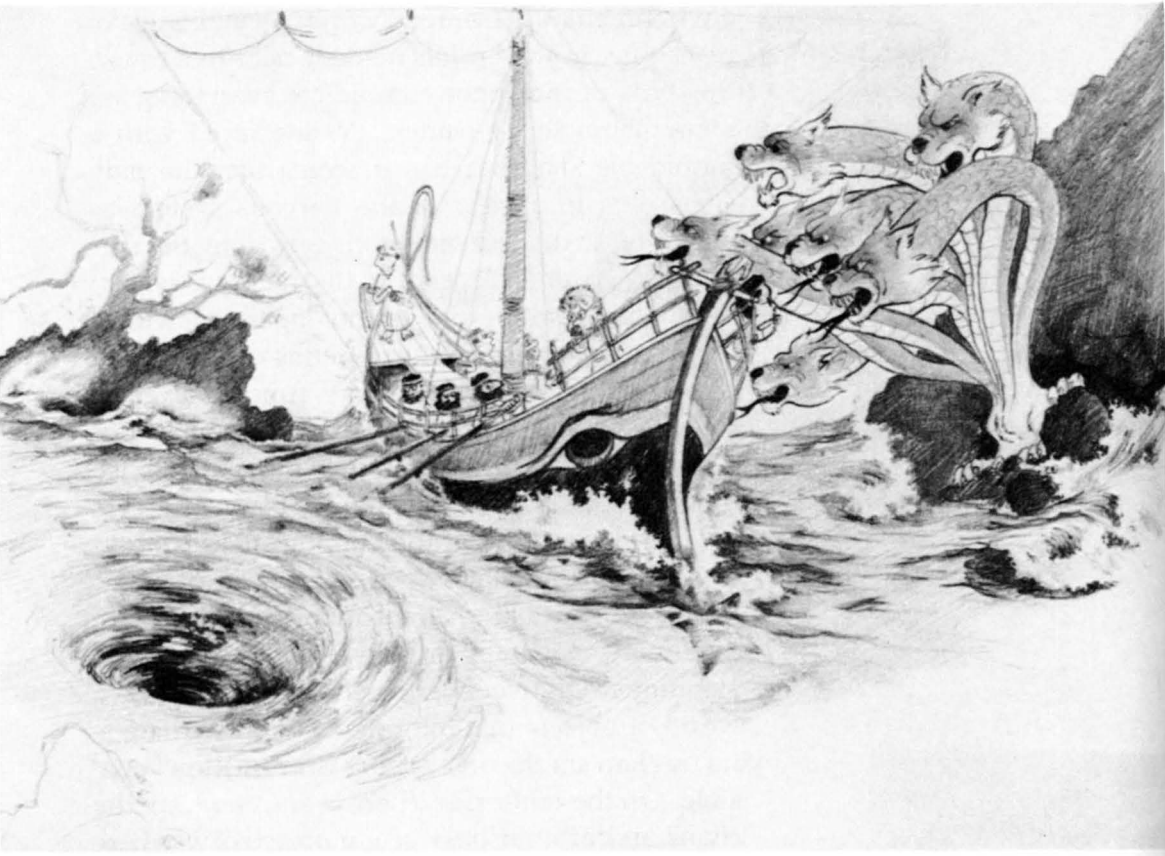


Fig. 35. The epistemologic Odyssey: sailing between the Scylla monster of representationism and the Charybdis whirlpool of solipsism.

thing is possible. This is the other extreme: absolute cognitive solitude or solipsism, the classic philosophic tradition which held that only one's interior life exists. And it is a trap because it does not allow us to explain how there is a due proportion or commensurability between the operation of the organism and its world.

Now, these two extremes or traps have existed from the very first attempts to understand cognition, even in its most classical roots. Today, the representational extreme prevails; at other times the opposing view prevailed.

We wish to propose now a way to cut this apparent Gordian knot and find a natural way to avoid the two abysses of the razor's edge. By now the attentive reader has surmised what we are going to say because it is contained in what we said before. The solution is to maintain a clear *logical accounting*. It means never losing sight of what we stated at the beginning: everything said is said by someone. The solution, like all solutions to apparent contradictions, lies in moving away from the opposition and changing the nature of the question, to embrace a broader context.

The situation is actually simple. As observers we can see a unity in *different* domains, depending on the distinctions we make. Thus, on the one hand, we can consider a system in that domain where its components operate, in the domain of its internal states and its structural changes. Thus considered, for the internal dynamics of the system, the environment does not exist; it is irrelevant. On the other hand, we can consider a unity that also interacts with its environment and describes its history of interactions with it. From this perspective in which the observer can establish relations between certain features of the environment and the behavior of the unity, the internal dynamics of that unity are irrelevant.

Neither of these two possible descriptions is a problem per se: both are necessary to complete our understanding of a unity. It is the observer who correlates them from his outside perspective. It is he who recognizes that the structure of the system determines its interactions by specifying which configurations of the environment can trigger structural changes in it. It is he who recognizes that the environment does not specify or direct the structural changes of a system. The

problem begins when we unknowingly go from one realm to the other and demand that the correspondences we establish between them (because we see these two realms simultaneously) be in fact a part of the operation of the unity—in this case, the organism and nervous system. If we are able to keep our logical accounting in order, this complication vanishes; we become aware of these two perspectives and relate them in a broader realm that we establish. In this way we do not need to fall back on representations or deny that the system operates in an environment that is familiar owing to its history of structural coupling.

Perhaps an analogy will clarify this. Imagine a person who has always lived in a submarine. He has never left it and has been trained how to handle it. Now, we are standing on the shore and see the submarine gracefully surfacing. We then get on the radio and tell the navigator inside: "Congratulations! You avoided the reefs and surfaced beautifully. You really know how to handle a submarine." The navigator in the submarine, however, is perplexed: "What's this about reefs and surfacing? All I did was push some levers and turn knobs and make certain relationships between indicators as I operated the levers and

submarine analogy

Behavior

By *behavior* we mean the changes of a living being's position or attitude, which an observer describes as movements or actions in relation to a certain environment.

knobs. It was all done in a prescribed sequence which I'm used to. I didn't do any special maneuver, and on top of that, you talk to me about a submarine. You must be kidding!"

All that exists for the man inside the submarine are indicator readings, their transitions, and ways of obtaining specific relations between them. It is only for us on the outside, who see how relations change between the submarine and its environment, that the submarine's behavior exists and that it appears more or less adequate according to the consequences involved. If we are to maintain logical accounting, we must not confuse the operation of the submarine itself and its dynamics of different states with its movements and changing positions in the environment. The dynamics of the submarine's different states, with its navigator who does not know the outside world, never occurs in an operation with representations of the world that the outside observer sees: it involves neither "beaches" nor "reefs" nor "surface" but only correlations between indicators within certain limits. Entities such as beaches, reefs, or surface are valid only for an outside observer, not for the submarine or for the navigator who functions as a component of it.

What is valid for the submarine in this analogy is valid also for all living systems: for the frog with the rotated eye, for the wolf girl, and for each one of us human beings.

Behavior and the Nervous System

What we call behavior in observing the changes of state of an organism in its environment corresponds to the description we make of the movements of the organism in an environment that we

indicate. Behavior is not something that the living being *does* in itself (for in it there are only internal structural changes) but something that we point to. Inasmuch as the changes of state of an organism (with or without a nervous system) depend on its structure and this structure depends on its history of structural coupling, changes of state of the organism in its environment will necessarily be suitable and familiar to it, independently of the behavior or environment we are describing. For this reason, if a behavior as a particular configuration of movements is to appear adequate, it will depend on the environment in which we describe it. The success or failure of a behavior is always defined by the expectations that the observer specifies. If the reader were in the desert and did the same movements and postures that he now adopts in reading this book, his behavior would not only be eccentric but pathologic.

Behavior is not something that the living being does ... but something that we point to

Thus, the behavior of living beings is not an invention of the nervous system and it is not exclusively associated with it, for the observer will see behavior when he looks at any living being in its environment. What the nervous system does is *expand* the realm of possible behaviors by endowing the organism with a tremendously versatile and plastic structure. This is the topic of the next chapter.