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CHAPTER TEN

The Brain, the Me, and the I

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> We have inherited from our forefathers the keen longing for unified, all embracing knowledge. . . . But the spread, both in width and depth, of the multifarious branches of knowledge during the last hundred odd years has confronted us with a queer dilemma. We feel clearly that we are only now beginning to acquire reliable material for welding together the sum total of all that is known into a whole; but, on the other hand, it has become next to impossible for a single mind fully to command more than a small specialized portion of it.
>
> I see no other escape from this dilemma (lest our true aim be lost forever) than that some of us should venture to embark on a synthesis of facts and theories, albeit with second hand and incomplete knowledge of some of them—and at the risk of making fools of ourselves.
>
> —SCHRODINGER (1944, p. 178)

PREAMBLE

When Raymond Bradley (1987) had finished a book relating his longitudinal studies of communes, Lois Erickson, a mutual friend of Bradley and Karl Pribam, asked Pribram to read it, hoping a recommendation for publication might develop. Pribram read the manuscript and was impressed with what appeared to him some basic commonality between the functional structures of social and neuronal collectives, between collectives of different levels or scales of system organization. Over the years, this commonality has become more and more striking—and, at the same time, more challenging.

The challenge is the following: General systems theory is based on the finding that often collectives of different scales can be shown to operate according to the same—or, at least, very similar—principles of organization. This is an intriguing finding but does not tell us *how—the process by which*—such operations come about.

In order to determine the "how" of processing, it becomes necessary to identify the transfer functions that make it possible for operations at one scale to influence those at the adjacent higher- and lower-order scales. A "scale" or "level" is defined as a "description" of the organization of the elements in a system that is simpler than a description of the elements themselves.

The recognition of multiple levels of organization in a system, is not, as Robert Hinde (1992, p. 1019) rightly points out, an argument for reductionism, because each level "must be thought of not as an entity but rather in terms of processes continually influenced by the dialectical relations between levels." Such an approach, which requires scientists to "cross and recross" the boundaries between levels (Hinde's phrase, quoted in Bateson, 1991, p. 14), thus demands integration between adjoining disciplines.

With respect to the challenge posed by relating social collectives to neural collectives, it thus became imperative, as a first step, to delineate scales intermediate between those describing the operations of communes and those describing the operations of the brains of the persons composing the communes. This chapter attempts such a delineation.

In this attempt, we were immediately faced with the problem of a plethora of different terms used in different scientific enterprises. It became critical to try to develop a uniform vocabulary for processes that seemed to us to characterize the same operations.[1] However, in doing this we may be treading close to what in philosophy is called theoretical reduction. But we are *not* reductionists in the sense that if we just knew everything there is to know at a particular level of inquiry, we would be able to explain everything at the next higher level. Rather, as Lévi-Strauss (1963) pointed out, this type of reduction may work for very simple systems (systems controlled by few variables). But for more diverse (complex) systems, a structural approach becomes necessary. The structural method places emphasis on the arrangement of *relations* among elements rather than on the elements per se. The classical example of this emphasis on relation is the periodic table in chemistry. Compounds—such as water—are composed of atoms joined in particular relations called bonds. The bonding is largely accounted for by the structure of—the number of protons in—the atoms composing the compound. But chemical science is basically a science of relations —of the nature of the bonding structures that compose molecules.

Another example is language, which is composed of some 20–30 phonemes. It is not these phonemes per se, however, that characterized a language. Rather, it is the relational structure, the ordering, and contextual embedding that make possible linguistic meaning.

Our approach, therefore, is based on the structural premise of *transposable invariance*: that "structure indicates an ordered arrangement of parts, which can be treated as transposable, being relatively invariant, while the parts themselves are variable" (Nadel, 1957, p. 8; see also Piaget, 1970). This is what makes it possible, for example, to describe the "structure of a tetrahedron without mentioning whether it is a crystal, a wooden block, or a soup cube" (Nadel, 1957, p. 7). Here, we are pursuing just such a structural approach. At the same time, we are nonetheless sympathetic to and uneasy with theoretical "reduction," which for us might better be called theoretical translation. In short, what we aim for is a translation of the concepts essential to understanding relations at one level of inquiry in order to articulate the meaning of concepts at an adjacent level.

INTRODUCTION

A few years back, one of us (KHP), during a seminar, noted that the left arm of a graduate student was moving somewhat awkwardly in arranging papers on the table in front of her. KHP asked the student, Ms. C., if she was all right, while pointing to her left arm. She replied, "Oh, that's just Alice; she doesn't live here anymore." At the end of the semester, Ms. C. presented a detailed account of her experiences with Alice, which is presented under "Some Case Histories."

Shortly thereafter, KHP was asked to supervise a graduate student at another university who was examining a boy *unable* to recount his experiences.

The two case histories provided the seed that provoked us to crystalize some latent ideas based on a wide range of data obtained on brain-lesioned monkeys, on brain electrical activity and the development of self in humans, and on factors leading to stability in social relationships and stability in social collectives. Our presentation is tentative but intrigues us sufficiently to venture it here.

The case histories describe two distinct modes of coping that are disrupted by brain injury: one articulates the organism—in egocentric space—and *locates* it—allocentrically—in its environment; the other *evaluates* and *monitors* experience. We proceed to suggest that these two dimensions of coping are embodiments of Piaget's processes of assimilation and accommodation. As accommodation is "the source of changes [that] bind the organism to successive constraints in the environment" (Piaget 1936/1954, p.

352), we explore the source in the consequences of behavior and the resulting changes in the organism's competence in assimilating (coping with) its environment.

Next, we note that this development of competence in assimilation entails three additional dimensions, dimensions that also have been shown to involve distinguishable brain systems: arousal–familiarization; activation–selective readiness; and effort–comfort. We go on to suggest that these dimensions are the same as those obtained by Sternberg (1986) in his analysis of the dimensions that lead to competence and stability in loving relationships: passion (arousal); commitment (selective readiness); and intimacy (effort-comfort). Finally, we relate these dimensions to those that have been shown to operate in producing stability in competent social collectives: flux (passion); control (commitment); and collaboration (intimacy).

SOME CASE HISTORIES

From Ms. C.:

> I was doing laundry about midmorning when I had a migraine. I felt a sharp pain in my left temple, and my left arm felt funny. I finished my laundry toward midafternoon and called my neurologist. He told me to go to the emergency room. I packed a few things and drove about 85 miles to the hospital where he is on staff (the nearest was 15 minutes away). In the ER, the same thing happened again. And again, the next morning after I was hospitalized, only it was worse. The diagnosis of a stroke came as a complete surprise to me because I felt fine, and I didn't notice anything different about myself. I remember having no emotional response to the news. I felt annoyed and more concerned about getting home, because I was in the process of moving.
>
> Not until several days later, while I was in rehabilitation, did I notice strange things happening to me. I was not frightened, angry, or annoyed. I didn't feel anything—nothing at all. Fourteen days after I was admitted to the hospital, I became extremely dizzy, and I felt I was falling out of my wheelchair. The floor was tilting to my left, and the wheelchair was sliding off the floor. Any stimulus on my left side or repetitive movement with my left arm caused a disturbance in my relationship with my environment. For instance, the room would tilt down to the left, and I felt my wheelchair sliding downhill on the floor, and I was falling out of my chair. I would become disoriented, could hardly speak, and my whole being seemed to enter a new dimension. When my left side was placed next to a wall or away from any stimuli, this disturbance would gradually disappear. During this period, the left hand would contract, and the arm would draw up next to my body. It didn't feel or look like it belonged to me. Harrison moved the left arm repeatedly with the same

> movement, and a similar behavior occurred, except I started crying. He asked me what was I feeling, and I said anger. In another test he started giving me a hard time until the same episode began to occur, and I began to cry. He asked me what I was feeling, and I said anger. Actually, I didn't feel the anger inside, but in my head when I began to cry. Not until I went back to school did I become aware of having no internal physical feelings.
>
> I call that arm Alice (Alice doesn't live here anymore)—the arm I don't like. It doesn't look like my arm and doesn't feel like my arm. I think it's ugly, and I wish it would go away. Whenever things go wrong, I'll slap it and say, "Bad Alice" or "It's Alice's fault." I never know what it's doing or where it is in space unless I am looking at it. I can use it, but I never do consciously, because I'm unaware of having a left arm. I don't neglect my left side, just Alice. Whatever it does, it does on its own, and most of the time, I don't know it's doing it. I'll be doing homework and then I'll take a sip of coffee. The cup will be empty. I was drinking coffee with that hand and didn't know it. Yet I take classical guitar lessons. I don't feel the strings or frets. I don't know where my fingers are, or what they are doing, but still I play.
>
> How do I live with an illness I'm not aware of having? How do I function when I'm not aware that I have deficits? How do I stay safe when I'm not aware of being in danger?

Ms. C. is obviously intelligent, attending lecture material, asking interesting questions. She is a widowed lady in her mid-50s, enrolled in adult education, majoring in clinical psychology. She gets around splendidly despite Alice and despite a history of a temporary left hemiparesis. The diagnosis was damage of the right temporal–parietal cortex confirmed by an abnormal electroencephalogram (EEG) recorded from that location. The damage was not sufficiently extensive to show in a positron-emission tomography (PET) scan.

Contrast Ms. C.'s story with the following observations made on an 8-year-old boy by Chuck Ahern as a part of a thesis program that KHP supervised:

> TJ had an agenesis of the corpus callosum with a midline cyst at birth. During the first six months of his life, two surgical procedures were carried out to drain the cyst. Recently performed Magnetic Resonance Imaging (MRI) showed considerable enlargement of the frontal horns of the lateral ventricle—somewhat more pronounced on the right. The orbital part of the frontal lobes appeared shrunken as did the medial surface of the temporal pole.
>
> TJ appears to have no ability for quantifying the passage of time [what Bergson (1922/65) called durée] and no experiential appreciation of the meaning of time units. For example, a few minutes after tutoring

begins, he cannot say—even remotely—how long it has been since the session started. He is as apt to answer this question in years as in minutes. He does always use one of seven terms of time quantification (seconds, minutes, hours, days, weeks, months or years) when asked to estimate the duration of an episode but uses them randomly. He can put these terms in order, but does not have any sense of their meaning or their numerical relationships to one another.

When TJ returned from a trip to the Bahamas he did recall that he had been on the trip; however, the details he could recount about the trip numbered fewer than 5. His estimates of how long it had been since his trip were typical in that they were inaccurate and wildly inconsistent on repeated trials. Also, the first five times back at tutoring he stated that he had not been at tutoring since his trip. It appears that he is unable to place in sequence those few past events that he can recall. Nonetheless, he can answer questions correctly based on his application of general knowledge about development, e.g., he knows he was a baby before he could talk because "everyone starts as a baby." But, one day he asked his tutor if he knew him when he was a kid, indicating, I think, his incomprehension of the duration of each of these developmental periods and his unawareness of what events constituted such a period for him.

TJ is aware that he has a past, that events have happened to him but he cannot recollect those events. He also spontaneously speaks of events in his future such as driving an automobile and dating and growing a beard. He has play-acted on separate occasions his own old age and death. TJ is capable of excitement about the immediate future. On the very day that he was going to the Bahamas he was very excited as he exclaimed repeatedly: "I'm going to the Bahamas." But when his tutor asked him when, he said blankly: "I don't know." He also displayed keen anticipation when one day he saw a helicopter preparing to take off from the hospital. The helicopter engines revved approximately 15 minutes before it took off and TJ become increasingly more vocal and motorically active, laughing as he repeated, "When's it going to take off?" He also anticipates future punishment when he is "bad." He is aware, on some level, of the immediate future in his constant question "What's next," which he asks his mother at the end of each activity.

There are a variety of other occasions on which he demonstrated this capacity regarding tempo (as opposed to evaluating the duration of an experience). There have been several breaks in his usual thrice weekly tutoring schedule. Each of four times this schedule has been interrupted, he has run to meet his tutor when he approached rather than waiting inside as he usually does. Also, on these occasions he has typically asked if his tutor missed him. However he states he does not know how long it has been since his last session, and there was no evidence that he knew it had been longer than usual.

TJ compares who walks faster or who draws faster. He has at least a basic sense of sequencing as when he says, "I'll take a turn and then you take a turn." He also uses terms like "soon" and "quick" correctly in con-

> versation. For example, when he wanted to do a drawing at the beginning of a session, and his tutor said that we needed to begin to work and he countered, "This will be quick." Unsurprisingly, he finished his drawing at his normal pace. He somehow seems to use such terms correctly without any experiential appreciation of them. (Modified from letter written by Chuck Ahern on March 19, 1995, addressed to Karl H. Pribram)

These two case histories illuminate two very important dimensions of self. One dimension, portrayed by Ms. C., *locates* us in the world and also with respect to our body's configural integrity. The other dimension, highlighted by TJ, *monitors* our experience. Without such monitoring, the events comprising the experience fail to become evaluated and encoded into memory. Location is kin to—but more primitive than—a spatial dimension[2]; monitoring is kin to—but more basic than—a temporal dimension.[3]

After I (KHP) read Ms. C.'s paper and gave her a well-deserved A+ and showed her Ahern's description of TJ, we discussed Dan Dennett's views—expressed in his book modestly entitled *Consciousness Explained* (1991)—on "the Cartesian Theater" and on "Narrative Consciousness." She agreed that the paper she wrote was indeed a narrative, but it had taken her a good while to piece together the various episodes that she had experienced into a coherent story. Meanwhile, and this was still the case, her experience was and is dramatically locational, that is, theatrical. What could provide better theater than "Alice doesn't live here anymore" with the emphasis on the "live *here*"? Despite the current vogue to trash Descartes (see, e.g., Antonio Damasio's *Descartes' Error* [1994][4]), many persons do, in fact, experience them*selves* as actors on the stage of life, as Shakespeare so eloquently expressed it.

Ms. C. experienced devastations to her locational *integrity*. Other patients, after injuries to their occipital lobes, demonstrate "blindsight," the ability to visually identify objects in the "blind" field despite the fact that they fail to be consciously aware of these objects. Patients such as those who are blindsighted and Ms. C., who might be considered to have a tactile and kinesthetic blindsight, both have damage to the cortex of the posterior convexity of their brains. Thus, they suffer disruption of their egocentric (essentially tactile and kinesthetic) and allocentric (essentially visual and auditory) organization. I (KHP) have called this a disruption of "objective" awareness because it relates the patient to his or her impairment as if it were a relationship among objects. The relationship is "intentional" in Brentano's (1874/1914) sense of an ability to differentiate the perceiver from the perceived (Pribram, 1976). Note that in such patients, narrative abilities do not suffer—as you can judge for yourself from Ms. C.'s report.

Contrast this with the boy's disability: This boy's episodic memory is severely deficient. But, as compared to Ms. C., he has no problem with his egocentric space, nor is he blindsighted —he has no difficulty in experiencing his allocentric whereabouts. Despite his disability in monitoring, he continually defines his location both in space and in clock-time. However, his narrative self is severely limited by his inability to monitor events and place them into sequences of episodes. The narrative self is composed of such sequences of episodes. TJ's attempts to do so are contrived and depend on his intact ability to deal with egocentric and allocentric experience.

To summarize this part of the chapter: Two dimensions of self can be distinguished on the basis of selective damage to different parts of the brain. These dimensions concern an objective "me" and a narrative "I."[5]

The *objective "me"* is characterized as spatiotemporally articulated (egocentrically) and located in the world (allocentrically). The *narrative "I,"* by contrast, is constituted by a hermeneutic monitor of episodes and events that themselves are the consequences of the monitoring, and thus self-organizing. Next, let us look into how these two dimensions of the self develop.

THE DEVELOPMENT OF A STABLE SELF

Piaget formulated two complementary processes that guide cognitive growth. One process he labels "accommodation"; the other, "assimilation." "In their initial directions, assimilation and accommodation are obviously opposed to one another, since assimilation is conservative and tends to subordinate the environment to the *organism as it is*, whereas accommodation is the source of changes and *bends the organism* to the successive constraints of the environment" (Piaget 1954, p. 352) Thus,

> the nursling's psychic activity is at first only simple assimilation of the external environment to the functioning of the organs. Through the medium of assimilatory schemata, at first fixed, then mobile, the child proceeds from this elementary assimilation to putting means and ends into relationships such that the assimilation of things to personal activity and the accommodation of schemata to the external environment find an increasingly stable balance. The undifferentiated and chaotic assimilation and accommodation which characterize the first months of life are superseded by assimilation and accommodation simultaneously dissociated and complementary. (Piaget 1954, p. 219)

With respect to the brain functions described here, assimilation appears to be affected by the process of locating the child in egocentric and allocentric space–time schemata; accommodation resembles the effect that a self-organizing, neurologically based monitoring hermeneutic process would be expected to exert.

Assimilation and accommodation are ordinarily complementary, and Piaget's developmental stages reflect this complementarity. Nonetheless, as Piaget points out in the preceding quotation, one can discern differences in balance: The sensory–motor stage is more assimilative than accommodative; the various operational stages employ both processes in a complementary fashion and more or less equally; and the postoperational stage(s) are primarily accommodative. In both assimilation and accommodation, biological and experiential factors interact, and the maturation of brain electrical activity reflects the resultant of this interaction. During infancy, maturation centers on the sensory–motor regions of the convexal cortex. In childhood and adolescence, two stages of "growth spurts," as they are called, can be discerned, each stage beginning posteriorly and ending frontally. Of great interest, and surprise, to us (Hudspeth & Pribram, 1992) was the discovery of a major increment in the maturation of the frontal cortex during the ages 17–21! This is the age at which we send our children to college (or to the armed services in case of war). Their accommodation is critically vulnerable, and how they mould their frontolimbic hermeneutic monitoring systems during these years will determine their citizenship for the rest of their lives.

This nice sequence of consequential events (events: Latin, *ex venire*: out-come) is, on occasion, interrupted. Interruption leads to a different process: The organism becomes aroused, demarcating an episode, but if the interruption is repeated, the organism habituates to it; the marked episode becomes familiar. When we remove one of the components of the frontolimbic forebrain (the amygdala), the organism's clock-like oscillations flatten out and familiarization fails to occur (reviewed by Pribram & McGuinness, 1975, 1992). Episodes become recurrent, distracting from the progressive development of competence through commitment; the organism has become hung up, treating each occurrence and reoccurrence of the distracting event as arousing. Interestingly, a kitten raised for 8 weeks in darkness and in an otherwise also restricted environment will, in the first few weeks of release, show symptoms identical to those of amygdalectomized cats: failure of visceroautonomic responses, continual and repetitious investigation of the environment (behavioral orienting), and a low threshold to startle (Konrad & Bagshaw, 1970).

Schore (1994), in an aptly titled volume, *Affect Regulation and the Origin of Self*, reviews additional evidence for the importance of the amygdala and related orbitofrontal systems in the development of the infant. Schore bases his analysis on the importance of the dyadic relationship between an infant and the primary caregiver. Through social bonding with the infant (touching, holding, feeding and especially mutual [eye] gazing, etc.), the primary caregiver creates a relationship with the infant that, according to Schore, involves interaction along two dimensions. The first is the stimulation of positive affect by the primary caregiver: this dimension seems to us to correspond to our arousal–familiarization dimension. Arousal involves establishing contexts to facilitate the dyadic mutual positive affect that becomes the conduit through which, according to Schore, the infant's worldly experience is channeled. The second dimension of this interaction is the regulation by the primary caregiver of the infant's behavior: This corresponds to what we have called a "readiness to selectively respond" system, which is centered on the basal ganglia of the brain. Schore describes interactions of the brain structures that become involved in these two processes:

> In line with the principle that information is processed in stages, the entire temporal sequence involves sensory–perceptual encoding of a socioaffective facial stimulus in the posterior cortex, cognitive appraisal in the frontolimbic anterior cortex, amplification of the signal during cortico–subcortical transmission along the visuolimbic pathway, activation of hypothalamic motivational systems which influence internal states and generate emotion–specific action tendencies, activation of the ascending ventral tegmental mesocortical dopamine circuit, and finally activation of prefrontal areas and frontal cortical motor regions responsible for facial and body emotion response expression. (pp. 195–196)[6]

Schore extensively reviews the evidence that "environmental stimuli regulate the anatomical, cellular, and even the molecular organization of the developing nervous system" (p. 161). With regard to the (dopaminergic) functions of the postnatal infant frontal cortex, the stimuli are primarily social. Thus, in situations where the primary caregiver's nurturing love has broken down during a critical period (approximately the first year of life) and the infant is subjected to prolonged exposure of heightened negative affect, the growth and organization of the infant's developing frontal cortex can be affected with enduring pathological consequences. This results in structurally defective neurobiological organization, which, in turn, produces disturbances in social attachments. These functional impairments of the neural circuitries result in a persisting susceptibility to further patterns of pathophysiological growth that are associated with later forming psychiatric disorders (see the review of the evidence by Schore, pp. 159–167).

To translate into the terms of this chapter, the requisite neurobiological organization for the development of a stable self is prompted by the interactions in the mother–infant dyad, which entail affect stimulation and modulation/regulation. Affect stimulation entails *accommodation by the* *infant to the egocentric and allocentric assimilation of his or her relation with the external world* and corresponds to arousal–familiarization. Accommodative modulation/regulation via the mother produces this egocentric and allocentric assimilation of the environment and corresponds to selective readiness. Often, it takes effort to disengage from the disposition toward arousal, that is, to return to commitment. Still another part of the forebrain (the hippocampal formation) is critical to determining the duration of engagement (Pribram & McGuinness, 1975, 1993). What is involved is the matching of the cycles of the clockwork to registrations in memopad. A model has been developed to detail how such a matching process might be articulated (Pribram, 1996). Thus, the infant's development of competence for (eventual) autonomous socio-emotional attachment corresponds to an effort–comfort dimension. More on this shortly.

Two further commonalities with Schore's findings should be noted. The first is that there is some evidence that the significance of these two dimensions of interaction continues beyond infant development to also be important in the development of the young child. Drawing from a study of aggression among 4-year-olds in preschools, Robert Hinde (1992) reports [on the basis of "three replications"] that aggression was found to lower when "maternal warmth" and "maternal control" in the mother–child relationship were "more or less in balance" (see pp. 1025–1026, especially Figure 5). The second is a commonality with Piaget's ideas on the role of affect in intellectual development. In his final lectures, Piaget (1983) links the development of the individual's intelligence and creativity as an adult to a nurturing fabric of loving relationships as a child.

THE ACCOMMODATIVE PROCESS

We have learned a good deal about the way accommodation is achieved. Reinforcement theory has made solid contributions to understanding, as have the results of neuropsychological experiments. In experimental psychology, reinforcements (and deterrents) are conceived as those consequences of behavior that influence an organism to increase (or decrease) the recurrence of the behavior that generated the consequence. Two separate processes are apparently involved: One is a biologically based, clocklike oscillator, the other a register or "memopad" that keeps track of the consequences per se. Many of the oscillations display an appetitive and a consummatory phase and are critical to organizing the accommodative process. The memopad registers an environmental event when it matches, that is, resonates with, the appropriate moment on the clock cycle. Recurrence of the consequential behavior is determined by the density of registrations (see Killeen, 1994, for review and details).

A ready way to conceptualize the reinforcement (or deterrent) process is as follows: (1) initially *consequences* are those sequences of behavior that fit into the context of prior registrations (thereby becoming consequential); (2) at a certain point, the density of such consequences attain a sufficient probability that the recurrence of the behavior will produce a reliable match, so that the organism becomes *confident* in its *competence* to perform in this context. At this point, the laws of learning are replaced by those that characterize performance (see Pribram, 1971, Chap. 16). The density of consequences engenders "affluence," which leads to such a means–ends reversal:

> What happens when a man, or for that matter an animal, has no need to work for a living? . . . The simplest case is that of the domesticated cat—a paradigm of affluent living more extreme than that of the horse or the cow. All basic needs of the domesticated cat are provided for almost before they are expressed. It is protected against danger and inclement weather. Its food is there before it is hungry or thirsty. What then does it do? How does it pass its time?
>
> We might expect that having taken its food in a perfunctory way it would curl up on its cushion and sleep until faint internal stimulation gave some information of the need for another perfunctory meal. But no, it does not just sleep. It prowls the garden and the woods killing young birds and mice. It *enjoys* life in its own way. The fact that life can be enjoyed, and is most enjoyed, by many living beings in the state of affluence (as defined) draws attention to the dramatic change that occurs in the working of the organic machinery at a certain stage of the evolutionary process. *This is the reversal of the means–end relation in behaviour.* In the state of nature the cat must kill to live. In the state of affluence it lives to kill. This happens with men. When men have no need to work for a living there are broadly only two things left to them to do. They can "play" and they can cultivate the arts. These are their two ways of enjoying life. It is true that many men work because they enjoy it, but in this case "work" has changed its meaning. It has become a form of "play." "Play" is characteristically an activity which is engaged in for its own sake—without concern for utility or any further end. "Work" is characteristically an activity in which effort is directed to the production of some utility in the simplest and easiest way. Hence the importance of ergonomics and work study—the objective of which is to reduce difficulty and save time. In play the activity is often directed to attaining a pointless objective in a difficult way, as when a golfer, using curious instruments, guides a small ball into a not much larger hole from remote distances and in the face of obstructions deliberately designed to make the operation as difficult as may be. This involves the reversal of the means–end relation. The "end"—getting the ball into the hole—is set up as a *means* to the new end, the real end, the enjoyment of difficult activity for its own sake. (Mace, 1962, pp. 10–11)

A somewhat similar statement has been presented by Robert W. White (1960). He emphasizes the role played by the progressive achievement of competence in the maintenance of behavior and makes a strong case that the "feeling of efficacy" is an important guide to behavior.

> Effectance is to be conceived as a neurogenic motive, in contrast to a viscerogenic one. It can be informally described as what the sensory–neuro–muscular system wants to do when it is not occupied with homeostatic business. Its adaptive significance lies in its promotion of spare-time behavior that leads to an extensive growth of competence, well beyond what could be learned in connection with drive-reduction. (White, 1960, p. 103)

White is concerned with the implications of effectance in clinical psychology; here, our concern is with what the sensory–neuromuscular system "wants."

According to the foregoing analysis, the common problem for means–end theory and effectance theory is that activities of a certain type appear to be self-maintaining. The consequences of the actions must provide their own set within which a subsequent event will be consequent, that is, reinforcing.

In many respects, what has been discussed is the development of behavior differentiation, that is, skill. Effectance and competence, play and gamemanship, demand precise timing of actions within larger sequences of actions, so that consequences—sequences in context—will form a harmonious production. And a great deal is known about the neurology of skill. Here, perhaps, more than anywhere else, the model of "sequence in context" can be realized in tissue—and in fact, the model was originally devised to handle some new neurological facts in this area (Miller, Galanter, & Pribram, 1960).

At the reflex level, control of muscular contraction can no longer be conceived simply in terms of the reflex arc (some excitation of receptors, transmission of the signal aroused by such excitation to the central nervous system, and back again to the muscle in question). The change in conception is necessitated by the discovery that the activity of the γ efferent fibers, fibers that transmit signals from the central nervous system to the receptors in the muscle (muscle spindles), acts as a feedback, that is, controls the amount of activity recordable from the afferents that signal the state of the receptor to the central nervous system. The presence of this feedback loop makes it difficult at any moment in time to assess the origin of a particular amount of activity in the afferent nerves, and thus the state of the receptor. That state could reflect the state of contraction (isometric or isotonic) of its muscle group or it could reflect the amount of activity of the γ efferent system, or both. Only a comparison between states at successive moments, in the context of γ efferent activity, will give a signal of the state of contraction of the muscle group. The γ efferent activity provides the setting, the context, the bias on the muscle receptor. (On occasion, the reverse may well be the case. The bias may be set by the muscle contraction and changes in γ efferent activity computed.)

Sherrington, in his classic lectures, *The Integrative Action of the Nervous System* (1911/1947), was not unaware of the problem, and his statement of it is worth repeating (his solution is cast in simple, associative terms—reinforcement for Sherrington occurs through immediate spinal induction [summation through increased intensity and coextensity of convergent inputs]):

> We note an orderly sequence of actions in the movement of animals, even in cases where every observer admits that the coordination is merely reflex. We see one act succeed another without confusion. Yet, tracing this sequence to its external causes, we recognize that the usual thing in nature is not for one exciting stimulus to begin immediately after another ceases, but for an array of environmental agents acting concurrently on the animal at any moment to exhibit correlative change in regard to it, so that one or other group of them becomes—generally by increase in intensity—temporarily prepotent. Thus there dominates now this group, now that group in turn. It may happen that one stimulus ceases coincidentally as another begins, but as a rule one stimulus overlaps another in regard to time. *Thus each reflex breaks in upon a condition of relative equilibrium, which latter is itself reflex.* In the simultaneous correlation of reflexes some reflexes combine harmoniously, being reactions that mutually reinforce [Sherrington, 1911/1947, p. 120; emphasis added].

At the cerebral level, also, neurology has a great deal to say about skill. Removals of the precentral "motor" cortex of primates (including man) certainly results in awkward performance (Pribram et al., 1955–56). It follows that in the cerebral mechanisms in control of action excitation "breaks in upon a condition of relative equilibrium." . . . This has been shown by John Lilly (1959). Prolonged trains of excitation (subliminal to those that would produce movement) were delivered to the precentral motor cortex whenever the lever was depressed by the subject (a monkey). Lever pressing had to be paced so the on–off nature of the excitation could be maintained. The monkey learned to perform such paced lever pressing behavior and spent many (may I say "happy"?) hours at this occupation.

This has been a long way from means–end reversal to effectance to skill. The point is simply that these areas of interest pose a common problem: how is it that selective behavior is maintained in the absence of guides from drive stimuli—or, in the extreme, when behavior apparently goes in a direction contrary to one plausibly related to drive stimuli? The

> suggestion made in this section is that the consequences of actions are truly stimulus events that occur in sequence and that, once some order has been initiated in this sequence of stimuli, this order per se can provide the set or context for the occurrence of the next or sub-sequent event. Actions have consequence and the consequences of actions are reinforcers. Behavior, thus, becomes its own guide. (Pribram, 1963, pp. 137–141)

The means–ends reversal based on confidence in one's competence can thus be defined in terms of the *density of consonant consequences* generated in a particular context. Other things being equal, the organism becomes committed to organize its actions not just to reduce dissonance but to actively produce consonance. The production of consonance is no haphazard affair—consequences will be registered when they match the organism's repertoire of behaviors relevant to its biologically based "interests" such as drinking or running. The more densely consonant become nested within the context, the framework, of the less densely consonant. (For a detailed review of the data upon which these ideas are based, see Pribram, 1980; 1995.) This nested hierarchical arrangement commits the organism to a Plan or program. The importance of Plans to the organization of behavior has been discussed fully in Miller et al. (1960). In addition, however, as noted here, consequential behavior is self-organizing, a theme that has been stressed by Konrad Lorenz (1969) and by Bandura (1991).

To summarize: Development concerns primarily the effect of changes occurring in the accommodative process as they alter assimilation. Accommodation is achieved by a process in which *con-sequences* (sequences of behavior that are consonant within the context created by prior consequences) become densely registered by virtue of their consonance. This process leads to *confidence*, which is based on the development of a behavioral *competence* in that context. The means–ends reversal *commits* the organism to pursuing the development of this competence. Commitment, therefore, is not to the status quo of current egocentric and allocentric, intentional competence but to a selective readiness to modify competence in accord with continuing assimilation of experience.

MODIFICATION OF ASSIMILATION BY ACCOMMODATION

In order for an assimilated content to be influenced by and to influence an accommodating context, sensory channels must be flexible in their organization. Evidence (from event-related brain electrical recordings, reviewed by Pribram, 1991, Lecture 10) indicates that updating occurs and thus calls into question the notion that processing capacity is inflexible. Additional evidence makes it unlikely that limitations in processing span are due to limitations imposed by some fixed channel capacity. Briefly, the evidence runs as follows:

Two million input nerve fibers converge by way of the central nervous system onto 350 thousand output fibers. Sherrington (1911/1947) conceptualized a restriction on performance due to this convergence in his doctrine of a "limited final common path." However, Donald Broadbent (1974) showed that with regard to cognitive operations such as attention, limited span is not so much a function of the final common path as it is a function of the central processing mechanisms in the brain. Broadbent reviewed this aspect of his work in the Neurosciences Study Program III (1974), and Pribram devoted a whole section of this program to the topic entitled "How Is It That Sensing So Much We Can Do So Little."

The issue of limited span is usually discussed in terms of a fixed channel capacity. But as reviewed by Pribram and McGuinness (1975, 1992), a considerable volume of work has shown that the central processing span is not fixed. Thus Miller (1956), Garner (1962), and Simon (1974, 1986), among others, have clearly shown that information-processing span can be enhanced by reorganization such as that provided by "chunking." In fact, the limitations in processing can be overcome to such an extent that one is hard put to defining any "ultimate" limit. These data and others have led us to conceptual limitations in processing span as limitations in channel competence rather than in channel capacity (Pribram & McGuinness, 1975), a view also expressed by Maffei (1985). Thus, the conception of a limited capacity depending on some fixed "exoskeleton" constraining channels becomes untenable. An increase in processing capability, in competence, becomes possible by way of challenges to a flexible "endoskeleton" supporting processing channels. Chunking has been shown, by neurobehavior experiments, to be influenced by resections of the far frontal cortex. Furthermore, electrical excitation of the frontal cortex changes receptive field properties of neurons in the sensory channels of the primary visual cortex. These changes are directly related to the ability to parse or chunk the input.

The particular experiments that demonstrate top-down neurophysiological processing—processing that implements changes in channel structure and, therefore, in egocentric and allocentric processing capability—were performed on the receptive field organization of single neurons in the lateral geniculate nucleus and the primary visual cortex of cats and monkeys. Receptive fields of visual cortex neurons were mapped by displaying a small moving dot on a contrasting background. The location and motion of the dot were computer controlled. Thus, the computer could sum (in a matrix of bins representing the range over which the dot was moved) the number of impulses generated by the neuron whose receptive field was being mapped. This was done for each position of the dot, because the computer "knew" where the dot was located (Lassonde, Ptito, & Pribram, 1981; Spinelli & Pribram, 1967).

The map obtained for the lateral geniculate nucleus (the halfway house between retina and cortex) is usually called the "Mexican hat" function for obvious reasons. The brim of the hat represents the spontaneous background of impulse activity of the neuron. The crown of the hat represents the excitation of the cell by the dot of light shown to the animal when the cell is located at the center of the visual field. Where the crown meets the brim, there is a depression indicating that the output of the cell has been inhibited.

It is this inhibitory surround that can be augmented or diminished by electrical excitation of other parts of the forebrain. Stimulation of the far frontal cortex or the head of the caudate nucleus diminishes the inhibitory surround; stimulation of the posterior intrinsic (association) cortex (specifically, in this case, the inferotemporal portion of this cortex) or of another of the basal ganglia, the putamen, produces an augmentation of the inhibitory surround.

Receptive fields of adjacent neurons overlap to a considerable extent. Thus, when the excitatory portion of the receptive fields becomes enlarged, the dendritic fields essentially merge into a more or less continuous functional field. By contrast, when the excitatory portion of the receptive fields shrinks, each neuron becomes functionally isolated from its neighbor.

This modifiability of the competence of the primary visual system was supported by testing the effects of the same electrical stimulations on the recovery cycles of the system as recorded with small macroelectrodes. Far frontal stimulations produce a slowing of recovery, whereas posterior stimulations result in a more rapid recovery as compared with an unstimulated baseline. Slow recovery indicates that the system is acting in unison; rapid recovery indicates that the system is "multiplexed"—that its channels are separated and not encumbered by a more extensively interconnected system with consequent greater inertia.

Further confirmation of the importance of frontal accommodative processing on posterior assimilatory functions has been provided by Tucker, Potts, and Posner (1995), who, recording on a 128-electrode geodesic array, used visual event-related brain electrical activity to study the course of this electrical activity in the brain. After an initial activity produced in the primary visual cortex in the occipital lobe, the frontal lobes became activated only to have the occipital cortex once more involved. This "reprise," as Tucker calls it, takes about 200 msec to occur. As yet, we do not know the pathways by which this occipital–frontal–occipital interaction takes place, nor whether the shape of the occipital reprise is altered by the frontal activity—but these issues are currently being investigated.

In summary, commitment entails accommodation of the competence of processing channels to assimilate progressively greater differentiation of the organism's egocentric and allocentric relationship to its environment.

STABILITY IN LOVE RELATIONSHIPS

So much for a top-down "deconstruction" of the accommodation–assimilation processes. We now take a bottom-up look to see how these processes influence social structures. Drawing on Sternberg's work on love relationships (1986; Sternberg & Barnes, 1985; Sternberg & Grajek, 1984), we now consider how the three dimensions we have just distinguished in brain systems–arousal–familiarization, activation–selective readiness, and effort–comfort—are, in essence, the same as the three dimensions that Sternberg has identified in his social-psychological research.

Grounded in the results of a series of empirical studies (Levinger, Rands, & Talaber, 1977; Rubin, 1970; Sternberg & Grajek, 1984; Sternberg & Barnes, 1985; and Swensen, 1972, among others), Sternberg (1986) has proposed a triarchical dimensionality to account for stability in love relationships. According to his "triangular theory," love has three components or dimensions. One is *passion*, which leads to romantic and physical attraction, and sexual intercourse. A second is *decision/commitment*, a cognitive component that involves two temporal considerations: a short-term decision that one loves someone else, and a long-term commitment to maintain that love. The third is *intimacy*, which refers to feelings of closeness, connectedness, and bondedness, feelings that give rise to the experience of warmth in a loving relationship. While the passion component of a close relationship is "relatively unstable," commitment and intimacy are "relatively stable" (Sternberg, 1986, pp. 119–122).

Constructing a taxonomy of eight kinds of love from the different (logical) combinations of the presence or absence of the three components in a relationship, Sternberg characterizes "consummate love," the category that involves the "full combination" of all three, as the ideal toward which most people strive in romantic relationships (1986, p. 124). And while noting that it may be easier to achieve consummate love than to maintain it on a long-term basis, he points out that the results from his empirical research (Sternberg & Barnes, 1985) suggest that the "ability to *communicate effectively* is almost a *sine qua non* of a successful loving relationship" (p. 134; emphasis added). The significance of this finding will become clear in the next section.

Translating Sternberg's dimensionality into our terms, there is a match between the "I" that becomes totally accommodative (the arousal–familiarization dimension), as developed here, and the "passion" dimension as portrayed in Sternberg's analysis. In a like manner, we would propose that commitment (by "me" to egocentrically and allocentrically assimilate—via selective readiness—the situation) as outlined in this chapter is equivalent to "decision/commitment" as developed in his analysis. Sternberg (1986, p. 134) indicates that this component is "most subject to conscious control" by an individual. Note that this type of conscious control corresponds to Brentano's (1973) intentionality and Searle's (1983) intention, as discussed earlier. Finally, there appears to be a close correspondence between the effort–comfort dimension, worked out on the basis of neuropsychological analysis, and the "intimacy" dimension in Sternberg's work. Intimacy often entails effort and can lead to comfort. Intimacy involves matching passion to commitment.

By way of summary, we have used Piaget's concepts of accommodation and assimilation as a framework of common terminology to translate concepts describing the operations of a particular scale or level of organization into the terms of those at an adjacent level. Thus, in describing, so far, operations at the neurobiological, neuropsychological, and social-psychological levels, we have endeavored to show correspondences in the organization of behavior that produce a stable, competent, social self. As we move to the final level, the sociological level of collective organization, it is worth noting that our approach is consistent with the strategy that Robert Hinde has often advocated (e.g., 1979, 1987, 1992; see Bateson, 1991, for examples), and our effort can be seen as an attempt to describe, in *substantive* terms, linkages between physiological, psychological, and sociological organization that Hinde (1992) identifies in his "levels of social complexity" framework.

In the next section, data from a longitudinal analysis of the factors leading to a stable order of collaboration in communes offer support for the correspondences we have established earlier. Interestingly enough, the data are also consistent with the notion of cooperation that Piaget develops in his essay, "Logical Operations and Social Life" (Piaget, 1965/1995a). Piaget's concept of cooperation, a "system of operations carried out in common" (p. 153) that is based on reciprocal interactions within the context of a common system of language, values, and social norms, is analogous to our concept of collaboration.[7]

STABILITY IN SOCIAL COLLECTIVES

Following up on previous analyses of the communes that Bradley studied (1987; Bradley & Roberts, 1989a, 1989b; Carlton-Ford, 1993; Zablocki, 1980), we (i.e., Bradley and Pribram) have developed an empirically based model of the endogenous processes of communication by which stability is generated in (small) social collectives (Bradley & Pribram, 1995, 1996). By communication, we mean a process by which information about the collective's internal organization is gathered, processed, and distributed throughout the collective as a whole. A "social collective" is defined as a durable arrangement of individuals distinguished by shared membership (a boundary) and collaboration in relation to a common purpose or goal. Stability is the degree to which structural integrity and functional viability are sustained by a collective over time.

The results from this earlier body of work have shown that two patterns of social relations form the communicative structure in stable communes. As shown for the stable communes (groups surviving at least 24 months beyond measurement of their social structure; see Figure 10.1),[8] one pattern is a dense web of mutual relations of positive affect interconnecting virtually all members. This web is organized as a *field*, a distributed, massively parallel order of symmetrical monitoring processes in which individuals are essentially interchangeable. The second pattern is a

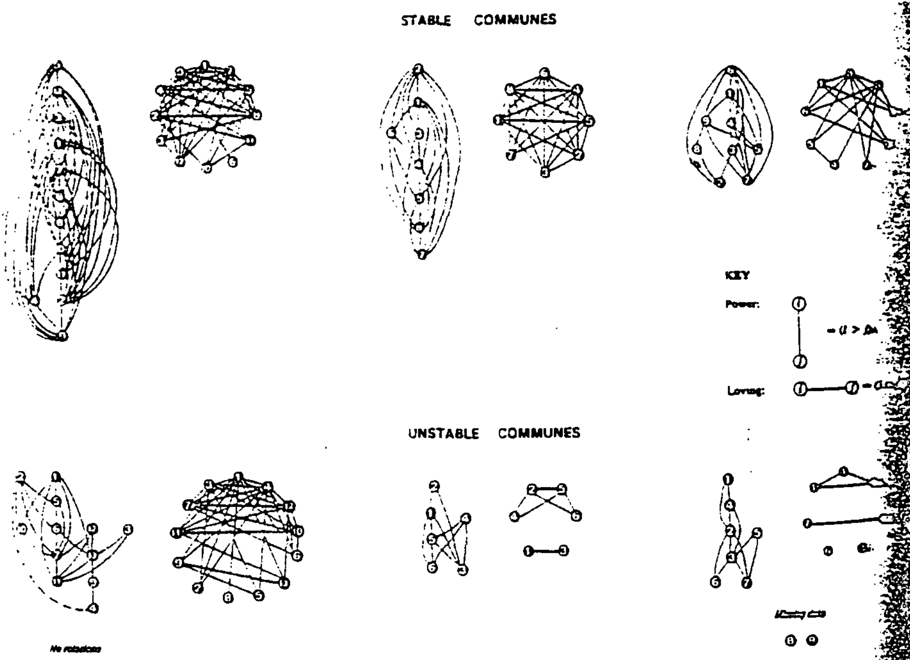

FIGURE 10.1. Sociometric structure of "loving" (flux) and "power" (control) relations for selected stable and unstable communes.

densely interlocking order of power relations that also extends to connect virtually all individuals. This is a *hierarchy*, a highly stratified system of asymmetrical, transitively ordered relations that define, for each individual, a location that is spatially and temporally identified and, therefore, unique. The relationship between the two orders was found to be associated with group survival (see Bradley 1987, Chap. 7; Bradley & Roberts, 1989a).[9] In following up on these earlier findings that describe *what* the communicative structure was composed of, we sought to understand how the interaction between field and hierarchy operates as an information processing system that *in*-forms (gives shape to) the production of stable collective order.

The *collaborations*[10] within the collective that form the communication system are formed by the interpenetration of networks of endogenous monitoring processes organized along two dimensions in which the values allocated in each dimension define points within a social field (Bradley & Roberts, 1989a). The values ascribed to the horizontal dimension represent *flux*, the amount of activation of potential energy (*passion*) in a social collective. The values ascribed to the vertical dimension represent the amount of *control* (*commitment*)—the degree to which individuals are interconnected by a transitively ordered network of relations—exercised at that location (see Figure 10.2). The coordinates representing the dimensions bound a phase space within which each value represents an amount of information—a *quantum* of information in Gabor's (1946) terms (see Appendix B)—that characterizes the communicative structure and *in*-forms the collective's expenditure of energy. Thus, each quantum of information, a configuration of flux and control, is associated with a potential for successful collaboration and, hence, stability of organization.

Using data from Bradley's (1987) nationwide longitudinal study of urban communes, we found strong correspondences between observed patterns of communication and group stability (see Figure 10.2). Sociometric data mapping all possible dyadic ties among adult members within each commune were used to construct structural measures (following Bradley & Roberts, 1989b) of flux (triads of mutual ties of positive affect: "loving," or "exciting," or "improving" relations) and control (transitively ordered triads of "power" relations); group stability (the minimum functional requirement of successful collaboration) was measured by survival status 24 months beyond the measurement of sociometric structure (for details, see Bradley & Pribram, 1995, 1996).

The scatterplot for the 46 communes in Figure 10.2 (the measure of control is plotted on the vertical ordinate, and flux is plotted on the horizontal ordinate; unstable, nonsurviving groups are shown as hollow dots) shows that the communes form a triangular pattern, and that those located in the peripheral areas are more likely to be unstable. This triangular re-

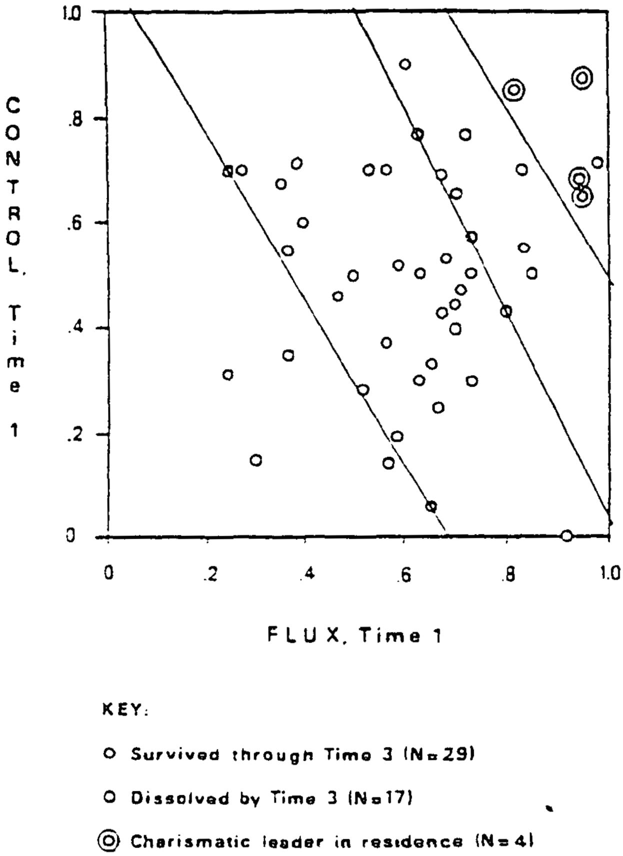

FIGURE 10.2. Scatterplot of communes on flux and control at Time 1. Stability (survival status) at Time 3 (24 months later) shows partitions for stability.

gion appears to be divided into two stable subregions, separated by zone of high instability. Beyond the zone of instability, in the apex of the triangle, are five communes, four of which had a charismatic leader in residence (shown with a circle in Figure 10.2) and were intent on achieving a radical restructuring of social order; the fifth group is a noncharismatic commune whose members expressed a strong desire for charismatic leadership as a means to facilitate their efforts at social change. The differences between these four groupings of communes in Figure 10.2, in terms of their patterns of flux, control, and stability, were found to be statistically significant (Bradley & Pribram, 1996).

A second, striking finding is that flux and control are predictive of stable collective organization (successful collaboration): that the relationship between flux and control at a given point in time was found to predict the survival status of communes 24 months in the future. This also is evident from the pattern of data in Figure 10.2. It is clearly apparent that the communes tend to cluster in the midregion of the field formed by flux and control, the area theoretically expected to be associated with efficient information processing. This region of optimal stability is consistent with thermodynamically inspired connectionist models of neural networks (e.g., Hopfield, 1982; Hinton & Sejnowski, 1986). In such models, *efficient pattern matching is found to occur in a region between total randomness and total organization*—in our terms, between rapid flux and rigid control. Moreover, it can be seen that location in the midregion (the area characterizing successful collaboration) is associated with a high probability of survival in the future.[11] However, this finding should *not* be taken to mean that the data generated by flux and control, at a given moment, necessarily enfold long-term information about collective order many months in the future. Rather, it is more likely that the efficiency of information processing in the midregion operates as an attractor.

To summarize: Our data concern the communicative structure formed by endogenous networks of interaction that monitor the activation and expenditure of energy by the collective. These endogenous processes are conceived to be based on the biological potential of the individuals composing the collective to engage in physical work, measured as energy. When activated by the collective, this biological energy is made available for the accommodation necessary for collaboration as a field of potential (passionate) energy. We have labeled this dimension of the endogenous order, flux.

In the other dimension, individuals are connected hierarchically. We have labeled this dimension control (commitment), because it appears to direct and assimilate the activation of the energy to the needs of the collective. Controls over the activation and distribution of flux result in social communication by way of quantum-like units of information (logons)—moment-by-moment descriptions, in terms of space-time and spectral coordinates, of the collective's endogenous organization.

The efficiency of the internal dynamics, and its relationship to collaboration, was found to display an optimal (energy conserving) combination of flux (passion) and control (commitment) that is associated with stable collective organization. Our empirical results thus show that for the group to survive as an effective collaborative unit, an efficient, self-maintaining communicative structure was required. Only those configurations of flux and control that produce a path of least action—one that entailed the smallest amount of turbulence—resulted in successful collaboration, and therefore, a stable, effective collective.

Despite a difference in focus—we focus primarily on the movements of energy and information in collaborative systems. Piaget (1965/1995b) focuses on the "operatory logic" in cooperative systems that underlies the development of thought and reason—a basic commonality is apparent. In Piaget's system of cooperation, reciprocity in "interindividual relations"—the free distribution and movement of information back and forth between individuals—is one of the two conditions for "equilibrium." This idea of a free exchange among individuals is analogous to our concept of flux. The second condition is a "common system of signs and references" (p. 148), namely, common language, values, and social norms. According to Piaget, the system of common signs and references acts as a constraint system, in our terms, control: It functions to "conserve" the operatory logic and outputs (what Piaget refers to as "propositions") of prior interactions, thereby acting to in-form the development and evolution of subsequent "cooperations." Thus, when reciprocal interactions are coupled with the information-conserving system of common sign and references, "mobile equilibrium" results, that is, stability in cooperative interindividual relations (pp. 145–153). In a personal communication from Inhelder, she stated that Piaget, after becoming acquainted with the ideas proposed by Prigogine (Prigogine & Stengers, 1984), agreed completely with a change in terminology for his (Piaget's) concepts from "equilibrium" to "stability far from equilibrium."

We have analyzed our data with regard to efficient communication within a collective but have, as yet, not addressed the effectiveness of social collectives with regard to the larger community within which they operate. This fascinating topic can now be studied within the purview of open, nonlinear systems dynamics. We plan to address this important question in a subsequent investigation.

CONCLUSION

At a time when cognitive science was just beginning to make a stir, Bill Estes and one of us (KHP) were asked to summarize a conference in Prague (then in Czechoslovakia). We looked at each other in dismay: Industrial, social, clinical, and a variety of breeds of experimental psychologists had presented a dense program that seemed to have little internal cohesion. As we puzzled and read our notes, it suddenly occurred to us that however diverse the presentations seemed, they did deal with issues in psychology, and that if we could define these issues, we might make a real contribution in our summaries. It turned out that there were only a half-dozen issues, and that we could rationally organize the Babel of discipline-specific terminologies around them.

In this chapter we have made a similar attempt. For years, we have felt that an affinity must exist between what the brain is doing to organize the behavior of organisms and the organization of social interactions among these organisms (Bradley & Pribram, 1988). Each discipline develops its own terminology; thus, the affinities must be sought in the issues the disciplines' data address, not in the terms used in the addressing. The danger is, of course, that surface similarities will obscure a search for deeper meanings, but, as in ordinary communication, a good place to *start* is to take the communication at face value.

Here, we have started with two case histories—exemplars of many clinical and experimental primate observations—and given our interpretation of the basic processes delineated by them. Our interpretation is couched in terms familiar to cognitive neuroscience. Because of our interest in development, we related this interpretation to that made by Piaget, whose work with Inhelder we have followed for many decades (see Bradley, 1987; McGuinness, Pribram, & Pirnazar [including the "endnote" by Inhelder], 1990; Pribram & Hudspeth, 1992). The connection between accommodation and the work on motivation and emotional controls on attention (Pribram & McGuinness, 1975, 1992) did not occur to us until we were preparing this chapter. Having made this connection, it was but a step to incorporating the data on love relationships and collaboration in social collectives (Figure 10.3)—a step we had been contemplating for several years (Bradley & Pribram, 1991).

To summarize: Neuropsychological observation and experimentation have distinguished two dimensions of self: on the one hand, an objective "me" that egocentrically articulates and allocentrically locates us in our environment, and on the other, a narrative "I" that monitors and evaluates that articulation. We suggest that these dimensions embody Piaget's assimilative and accommodative developmental processes. As it is accommodation that changes the organism's competence in assimilating the environment, we inquired as to how the accommodative process works, how competence becomes updated. We found the answers in our own neuropsychological data and those reviewed by Schore: three additional dimensions were discerned, (1) arousal–familiarization, (2) activation–selective readiness, and (3) effort–comfort. We further claimed that arousal leading to familiarization is the essence of accommodation: that activation of selective readiness is the essence of assimilation; and that effort–comfort mediates between accommodation and assimilation. Finally, we became intrigued with the similarity between these dimensions and those developed by Sternberg in investigations on the stability of love relationships that were relevant to our investigations on stability in social collectives. We believe that the connection between the neuropsychological dimensions and those

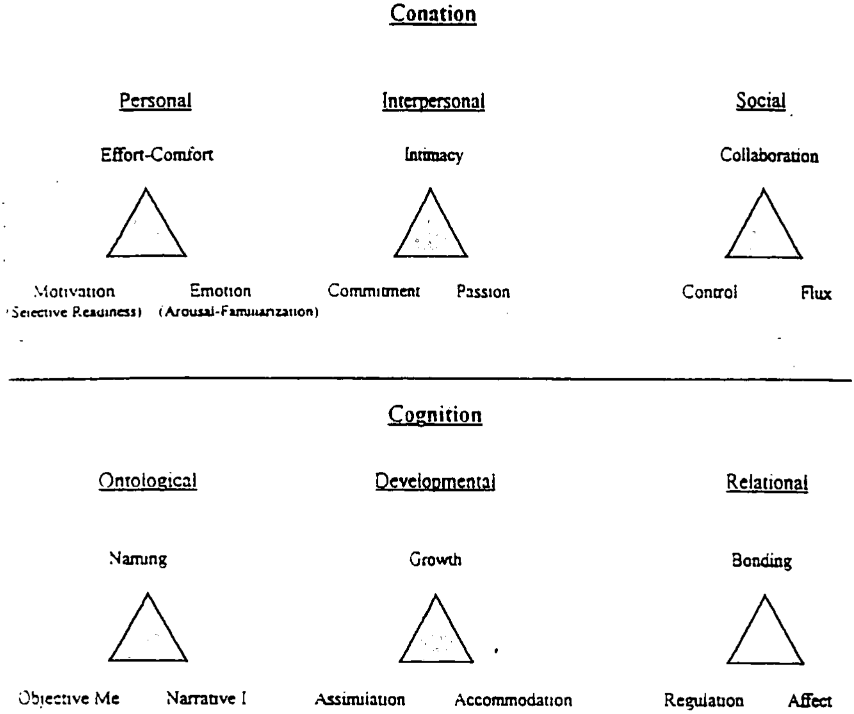

FIGURE 10.3. Diagrams of triarchical structures describing cognitive and conative processes.

obtained on the social psychology of love suggest the following correspondences: arousal with passion; selective readiness with commitment; and effort–comfort with intimacy. Moreover, based on the relational predictors of stability in social collectives, we further believe that these correspondences can be extended to include sociological dimensions of collective organization—to wit: arousal–familiarization to accommodation, to passion, and to flux; selective readiness to assimilation, to commitment, and to control; and effort–comfort to stability, to intimacy, and to communicative collaboration (see Figure 10.4).

Though the techniques of data collection are to some extent different, the relevance of the Sternberg data to those derived from social collectives, because both were obtained from dyads, makes this comparison robust. The connection between brain science and social science through neuropsychological and cognitive-developmental investigations, such as we make here, are more speculative, but we believe that they will prove to hold explanations that cannot be arrived at in any other way.

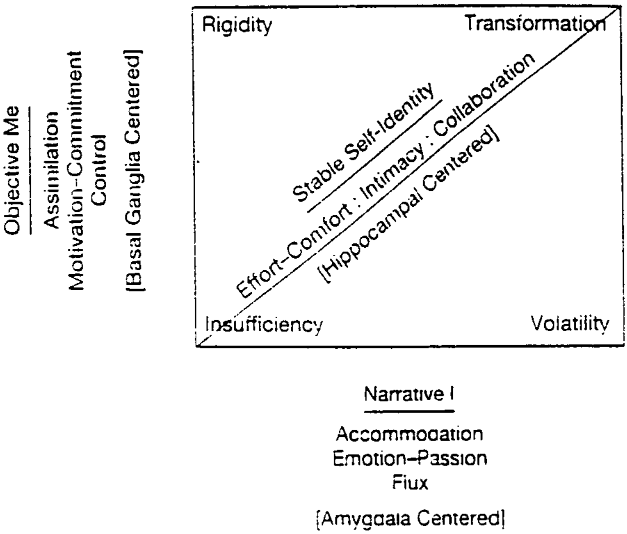

FIGURE 10.4. Speculative diagram of relations between triarchical structures at various scales (levels) of inquiry and the resultant effects on stability

APPENDIX A[12]

The ubiquitous role of quantum mechanics in neurobiology is obvious. Every time a photon enters the eye, an energy transaction obeying the law $E = h\nu$ takes place. The last 50 years have increasingly revealed that the role played by quantum mechanics in all of biology is significant. As Schrödinger wrote in 1946, "The mechanism of heredity is closely related to, nay founded on the very basis of quantum theory" (Schrödinger, 1946, p. 47).

The possibility that processes in the brain's connection web may result in the transmission of photons of frequencies in the 10^{13} Hz, i.e., far-infrared range, was suggested by Fernandez–Moran in 1951, and has been increasingly borne out. In 1960 Wiener wrote: ". . . the active bearer of the specificity of a molecule may lie in the frequency pattern of its molecular radiation, an important part of which may lie in the infrared electromagnetic range or even lower" [p. 52].

Since the late 1960's Fröhlich's researches have confirmed collective behavior of assemblies of biomolecules resulting in long-range coherent radiation in the 10^{11} Hz range. And in the 1980's Adey suggested that coherent infrared radiation could be the basis of intracellular signaling and energy transfer over short distances. The quantum role is further addressed in the papers of Jibu, Yasue, and Pribram (1993, 1996).

We must, however note that the *phase* of the undulations is conspicuously absent from the Planck–Einstein equations. To an extent this missing phase is restored in the researches of Fröhlich by virtue of his emphasis on coherence. But the tendency in quantum mechanical circles has been to ignore the phase of the de Broglie wave, and attribute significance only to its frequency, wavelength, and the non-negative square of its amplitude. Aside from a few great physicists such as Born, Dirac, and Feynman, the common attitude has been to dismiss rather naively the de Broglie wave as a mathematical "tool."

It was the pioneering thought of Haldane (1934) that *the full-fledged de Broglie wave (with frequency, wavelength, amplitude and phase) is involved in all phenomena in the universe*, and thus the phase of the de Broglie wave is most germane to the understanding of cognitive processes. More precisely, what Haldane proposed was that the resonances of the de Broglie wave systems of highly organized material systems constitute their potential for "mental" prowess. His pithy paper (Haldane, 1934) therefore merits a brief digression on our part.

The central theme of Haldane's paper is that the wave-mechanics of de Broglie and Schrödinger can explain the phenomena of both life and mind. He admits as limiting extremes the billiard-ball atomism of Lucretius and Newton on the one hand, and, on the other, the ideal world of Plato, these limits being attained as the mass–energy of the system is allowed to tend to zero or infinity, respectively. The fact that the universe is in-between these extremes is what makes life and mind possible. Recall in this regard, that posterior and frontal lobe stimulation of the brain can bring about tendencies toward these extremes of conscious processing (Pribram, 1991; Lecture 10).

APPENDIX B[13]

Gabor's discovery was based on the fact that the Fourier theorem opposes two different orders, two different ways in which signals become organized. In Lecture 3, we became acquainted with these two domains as characterizing the input to and output from a lens that performs a Fourier transform. On one side of the transform lies the space–time order we ordinarily perceive. On the other side lies a distributed enfolded holographic-like order referred to as the frequency or spectral domain.

Gabor (1946), as had Heisenberg and Hilbert before him, chose to represent the spectral and space–time orders by orthogonal coordinates, thus forming a phase space. Gabor was intrigued by the fact that in psychophysics, as in quantum physics, one could accurately determine either frequency (e.g., of a tone) or time (e.g., of its occurrence) but not both. Thus an uncertainty principle holds for psychophysics as well as for quantum physics:

In Gabor's own words published in 1946:

> Fourier's theorem makes of description in time and description by the spectrum, two mutually exclusive methods. If the term "frequency" is used in the strict

> mathematical sense which applies only to infinite wave-trains, a "changing frequency" becomes a contradiction in terms, as it is a statement involving both time and frequency.
>
> The terminology of physics has never completely adapted itself to this rigorous mathematical definition of "frequency." For instance, speech and music have a definite "time pattern" as well as a frequency pattern. It is possible to leave the time pattern unchanged, and double what we generally call "frequencies" by playing a musical piece on the piano an octave higher, or conversely, it can be played in the same key, but in different time.
>
> Let us now tentatively adopt the view that both time and frequency are legitimate references for describing a signal and illustrate this—by taking them as orthogonal coordinates. In this diagram harmonic oscillation is represented by a vertical line. Its frequency is exactly defined while its epoch is entirely undefined. A sudden surge or "delta function" (also called "unit impulse function"), on the other hand, has a sharply defined epoch, but its energy is distributed over the whole frequency spectrum. This signal is therefore represented by a horizontal line. (p. 431)

> Changing from a function of either [Space]time *or* frequency [as in the Fourier relation]—[to] a function of two variables—[space]time *and* frequency—[we compose a phase space]. [Thus] we have the strange feature that, although we can carry out the analysis with any degree of accuracy in the [space]time direction or the frequency direction, we cannot carry it out simultaneously in both beyond a certain limit. In fact, the mathematical apparatus adequate for treating this diagram in a quantitative way has become available only fairly recently to physicists, thanks to the development of quantum physics.
>
> The linkage between the uncertainties in the definition of "[space]time" and "frequency" has never passed entirely unnoticed by physicists. It is the key to the problem of the "coherence length" of wave trains. . . . But these problems came into the focus of physical interest only with the discovery of wave mechanics, and especially by the formulation of Heisenberg's principle of indeterminacy in 1927. This discovery led to a great simplification in the mathematical apparatus of quantum theory, which was recast in a form of which use will be made in the present paper. (p. 432)

Gabor defined his elementary function, as a *logon* or quantum of information.

NOTES

1. Recently there has been a growing recognition among scientists (e.g., Barkow, Cosmides, & Tooby, 1992; Goldsmith, 1991; Kauffman, 1995) and philosophers (e.g. Searle, 1995) of the importance of developing a common language and set of common principles of organization by which studies in the natural and social sciences can be integrated.

2. This locational dimension includes clock-time, what the Greeks called chronos and Minkowski and Einstein related to space. Location for a moving organism is always in space-time.

3. Monitoring entails not only the experiencing of duration but also the decisive moment: what the Greeks referred to as *Kairos*. The dictionary defines "moni-

tor" as follows: a device to record or control a process; to check for significant content.

4. Descartes's "cogito ergo sum" is currently taken to mean *cogito* as a purely cognitive dimension. But *cogito* is not *cognito*. As Freud described in his "Project for a Scientific Psychology," there are several types of thinking that are purely emotive: for example, circular ruminations that give evidence of a "hang up" (see Pribram & Gill, 1976). So, despite the sharp separation between feeling and reason during the enlightenment, this distinction need not have carried over to the production of thought. It is only in the late 20th century that *cogito*, thought, has been exclusively identified with logic and cognition (see also Weiskrantz, 1988).

As to Cartesian dualism, its origins in propositional utterances is traced in Pribram (1963, 1971). On the issue of elemental nonphysical "substance," our modern understanding of electricity has totally undermined earlier views on "spirit." With regard to this, and the intimate place of body in mind, Damasio's illumination of Descartes's error is, of course, correct. But we may be equally wrong in going to the opposite extreme—when we interpret radiant energy, massless bosons, to be material substance (see Pribram, 1996). Should current speculation on the role of Einstein–Bose condensation in promoting superconductivity in neural membranes (especially in dendrites) be correct, a bosonic, soft photon, "nonmaterial" aspect of neural functioning in the generation of thought may yet have to be seriously considered in the philosophy of mind (Jibu, Hagan, Hameroff, Pribam, & Yasue, 1994; Jibue, Pribam, & Yasue, in press; see also Appendix A).

5. An excellent review of the history of differentiating an objective "me" from a hermeneutic (interpretive) "I" can be found in Hermans, Kempen, and Van Loon (1992).

6. We quote Schore's paragraph in full so that the reader can see that we are not the only authors who construct unintelligible sentences to describe the intricacies of the impossibly complicated interactions among brain structures that underlie every psychological process.

7. Searle's (1995) recent account of the construction of social reality is also based on a relational logic he finds in cooperative interactions. Searle argues that "genuine cooperative behavior" is the basis for a nonreductionist order of social life that he calls "collective intentionality": "The crucial element in collective intentionality is a sense of doing (wanting, believing, etc.) something together, and the individual intentionality that each person has is derived *from* the collective intentionality that they share" (1995, pp. 24–25; emphasis in original).

8. The sociograms in Figure 10.1 were constructed from sociometric enumeration of all possible pairwise relations (dyads) in which each adult member was asked a set of standardized questions about his or her relationship with each other member. See Bradley (1987) or Bradley and Roberts (1989b) for further details.

9. A similar finding, documenting the importance of both reciprocity (monitoring processes) and transitivity (location in social space) in communication, was made by Rice (1982) in a study of networking in computer conferencing systems.

10. The term collaboration is derived from the French verb *collaborer* and means working (*laborer*) together (*col*) to produce (Fowler & Fowler, 1964, p. 234). See Roberts and Bradley (1991) for a full discussion of collaboration as a sociological concept.

11. The three lines shown marking the boundaries of the regions in Figure 10.2 were established by dividing the full sample of 46 communes into stable and unstable sets such that the probability of survival for the former was maximized, while being minimized for the latter. Discriminant analysis, comparing the four grouping of communes separated by the lines, provided a strong statistical confirmation of these results as 45 (98%) of the 46 communes were correctly classified by two canonical discriminant functions constructed from the measures of flux and control. It is worth noting that *none* of the other nine sociological variables (measuring aspects of ideological orientation, normative regulation, formal organization, structural characteristics, and member commitment) investigated in this analysis met the statistical criteria for inclusion in the multivariate stepwise procedure. A split-sample reliability analysis confirmed the generalizability of these results (see Bradley & Pribram, 1996).

12. From Pribram (1997, pp. 317–318). Copyright 1996 by American Mathematical Society. Reprinted by permission.

13. From Pribram (1991, pp. 70–71). Copyright 1991 by K. H. Pribram. Reprinted by permission.

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