Roland Fischer

EMERGENCE OF MIND FROM BRAIN

THE BIOLOGICAL ROOTS OF THE HERMENEUTIC CIRCLE

Brain functions are stochastic processes without intentionality whereas mind emerges from brain functions as a Hegelian "change from quantity", that is, on the order of 10^{12} profusely interconnected neurons, "into a new quality": the collective phenomenon of the brain's self-experience. This self-referential and self-observing quality we have in mind is capable of (recursively) observing its self-observations, i.e., interpreting change that is meaningful in relation to itself. The notion of self-interpretation embodies the idea of a "hermeneutic circle", that is, (in interpretation theory) the treatment of the whole in relation to its parts.

Brain processes become intelligible within the context of mind function, while the entire context of mind becomes intelligible through individual brain processes (we have in mind). These thoughts reflect an analogy: the feedback loop on a cybernetic

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control system that regulates and thus redefines (in our mind) the meanings of the whole in relation to its parts.

Wearing distorting prism spectacles results in distorted images on the retina that gradually disappear, however, when the subject is free to move. Such visual-cortical correction of distorted images on the subcortical retina or counteradaptation exemplifies the "hermeneutic circle" or the operation of a cybernetic control system that through feedback from head and limb movements redefines perception as a whole in relation to its parts (as represented in past experience). The interpretative repertoire of past experiences is a *sine qua non* of hermeneutic "pre-understanding" (from the German *Vor-Verständnis*); it refers to the capability of inferential reconstruction that is involved in the task of interpretation.

It is well known that texts can only be read in connection with or against other texts read in the past (intertextuality). Analogously, perceptions have to be interpreted in the light of past perceptions; excitatory perturbations have to be matched with expectations based on past excitations; and sensations may become perceptions only when appropriate behavior is available (from past experience) for sensory-motor closure. These aspects of non-localizable mind function are attempts at describing the creative act of grasping (from the Latin *capio, concapio*, concept), that is, a unitary act of construction and inferential reconstruction conferring meaning to matter or any thing that matters.

At the threshold of brain and mind

> "There's someone in my head but it's not me"
> (Pink Floyd: *Dark Side of the Moon*)

Whenever we attempt to perceive-conceive the perceptual cognitive performance of our own nervous system, that is, whenever the brain-mind looks into a mirror that is itself, a transformation—from observer to interpreting narrator—occurs. We can clearly *observe* how a stimulus "from the outside" initiates a predictable chain of events, and can describe these events in neurophysiological terms but, alas, only up to the fifth or sixth synapse (Haber, 1979, p. 263). At this point we seem to have arrived at the threshold of brain and mind where the mirror of recursive feedback loops folds upon itself and self-referential reflection compels us to switch from a language that describes objectively the brain function to a (meta-)language of self-reflecting brain function. Now we have to use words like "recognition", "identification", "experience", and so forth, i.e. words that are made to fit the language of an inside interpreter who can recognize, identify, and so forth and is capable of denoting things while being conscious of the act of denotation. This interpreting narrator is truly both object and subject (Fischer, 1986 a).

We may approach the transformation from observer to narrator by emphasizing the existence in neural tissue of self-adjusting feedback systems with built-in criteria of expected, that is, goal-directed performance. They are the circuits of experienced self-reflexivity, a very common property of neural tissue. For example, some of the outputs of the somatosensory cortical receiving area are nerve fibers which modulate the activity of their own sources of input (Towe, 1973: Gordon, 1978).

Could it be then that mind emerges from non-linear oscillatory brain processes elicited through an increase in iteractions of self-referential feedback systems that "bifurcate" after the fifth or sixth synapse? Such an assumption could help to account for another related puzzle. Penfield (1968), when applying electrical stimulation to certain areas of the brain, caused his patient's hand to move, but the patient did not feel that he was willing the movement ("you made me move it"). It would not be remarkable to find—comments Glassman (1983)—that a patient can sense the extrinsic origin of a movement elicited by electrical stimulation of the motor cortex pyramidal cells that are only *two* synapses away from the muscles. But there are areas of the brain *further* removed from motor outputs or sensory inputs, where stimulation yields effects that might easily be interpreted as tampering with the (self-reflective) will. It appears that within a hierarchically organized central nervous system (CNS) an increase in the number of firing synaptic circuits and feedback sub-systems allows *quantity* to change into *quality*—reflex to become self-reflexivity—and thus mind emerges from brain function (Fischer, 1986 b).

Is such emergence comparable to musical experience emerging from the (nervous) conducting of an orchestra (Aboitiz, 1985)?

And does it make sense to correlate or to map the syntax of the operations of the nervous system (the orchestra) with or into the semantics of the behavior it generates (the musical experience)? The phenomenal domain where the coordination of musicians takes place (brain function) is not the same domain as the one where the symphony exists as a musical experience (mind function). These are non-intersecting domains (Maturana, 1985) and, accordingly, a map showing localized brain functions based on electroencephalography (EEG) does not match the functions mapped on the basis of specific brain lesions.

Maybe lesions interfere with the conducting of the DNS orchestra, that is, lesions interfere with brain function while EEG maps, although displaying artefacts, are echoing important bifurcations and catastrophic jumps within (mind function). Oscillating biological systems or time patterns of the brain that are in dynamic equilibrium with phenomena of the world may represent states of self-knowing of the mind. Perceptual-cognitive problem-solving or interpretive operations, therefore, (but aesthetic experiences as well) may be definite states of equilibria that produce satisfaction: terminal unity of operations culminating in steady state condition toward which oscillating neuronal firing patterns are proceeding. Such oscillating systems have attractors which can bifurcate. Although we cannot measure those attractors, we can sometimes catch their bifurcations by means of artefacts and EEG patterns are just such artefacts. Hence, although the artefact may be but a pale shadow of the internal dynamics, yet its catastrophes may furnish a reflection of significant events (Zeeman, 1975). In this sense the underlying artefact may provide a non-trivial model of mind function.

Mind is not here ... it is not there ... it is nowhere and everywhere

Talking about "mind" in the third person as something that is (or is not) localized *in* the head, reflects formal thinking that is based on spatial and local concatenations of forms. But concepts like mind order complexity, information, meaning, randomness, life and so forth, share morphologically a common non-local (trans-spatial) feature. Hence, non-localizable behavior, like mind,

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should not be addressed in the third person, that is, a grammatical form whose function is to express the non-person (Benveniste, 1971; p. 228), a form that precludes all self-reflexive movement. Such "mind" is too all-embracing a metaphor and without any explanatory power.[1]

Non-linear, superadditive behavior of systems cannot be located within their specific parts since it is inherent in, and a property of, the complex integrity of the whole system. We can illustrate the foregoing with Woodger's "equimo" (Rothstein, 1968), that denotes *a system* arising from the combination of horse (*equus*) and man (*homo*). The equimo can diplay non-linear superadditive behaviors, foxhunting, for example, that cannot be localized since it is inherent in, and a property of, the whole system. An attempt to correlate, for example, the pupil size, or the galloping rate, of the equimo with its foxhunting behavior (expressed in number of foxes killed) is a classical example of a psychophysical correlation, that is, the unjustified attempt to relate the linear functioning of part of the system's structure with non-linear behavior (the fox-hunting mind) resulting from the complex integrity of the whole system. The foxhunting mind is neither in the horse nor in the rider but *is* the behavior of the equimo in action.

To sum up, the mind *is* the behavior. The mind is in "every heart beat, every twitch of a muscle, every movement and posture... [it] is an integral part of the total behavior which evolves and proceeds as unity in time" (Yakovlev, 1948, p. 315).

Our definition of mind as behavior acknowledges the two-fold meaning of the German word *Haltung*, that is, external posture (objective behavior) as well as inner attitude (subjective behavior). Both meanings of *Haltung* (motion and emotion) are implicit in *Verhalten*, that is, behavior.

And in what do brain functions differ from mind function? Brain functions are cerebral processes that are not correlates of conscious experience. Mind function proceeds on the interpretative, self-controlling level, and is—in paraphrasing Donald McKay

[1] Mind cannot be localized, neither can it—when designated, for example, with the pronoun "I"—"mean" and "be" simultaneously in time. Note the boldness of Lacan when rewriting Descartes, "I think, therefore I am" as: "I am not where I think" hence "I think where I am not".

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(1985)—embodied in stochastic brain processes in which the setting for criteria of hermeneutic self-interpretation is not triggered until some prior physical process reaches a critical threshold. It is at this critical threshold that Hegelian quantity—on the order of 10^{12} profusely interconnected neurons—is changing into a new quality: self-awareness or consciousness.

The notion of non-localizability is far from being a novel concept. Although—the nowadays much maligned—Descartes in a letter to Meyssonier, dated January 29, 1640 (Descartes, 1976, p. 62), compares the "impressions reserved in memory" to folds which "remain in the paper after it has once been folded", and these "folds" appear as modern as yesterday's engrams and traces. Descartes takes the view that the traces may be located *throughout the brain* and even in other parts of the *body*: "for instance, the skill of a lute player is not only in his head but partly in the muscles of his hand, and so on", that is, the lute player's mind is lute-playing behavior.

Descartes (1951), in his *Second Meditation*—published 1641—after having observed and pondered the sensible changes in a bit of wax that is brought close to the fire, comes to the conclusion: "I now know myself: since all the reasons which help me to know and conceive the nature of the wax, or of any other body whatsoever, serve much better to show the nature of my mind". What Descartes, in fact, had meant to say was that the logic of the description (of the melting wax) is isomorphic with the logic of the describing mind; or more generally: what we call a law of nature is rather a law of our own nature (because it is prescribed and described by our own nature).

Peirce (1984, p. 2411)—around the middle of the 19th century—is even more explicit when stating the identity of man and the word or sign that man uses: they are identical in the same sense in which the words *homo* and man are identical. *Nosce te ipsum*! Know thyself! Sensory motor interactions (or closures) are "objects", i.e. representations that exist within ourselves and, therefore, the cosmos is an internalized system of representations or signs. They become meaningful when the attentional and arousal systems of the CNS transform the cosmic sign system into a sign system of experienced meaning.

Psychoactive drugs of the LSD and psilocybin type, by raising

CNS arousal, will intensify the meaning of each and every sign or representation. Without drug-influence, however, the central sympathetic (attentional) arousal system of the CNS is going to intensify the meaning of only those signs that stand for values that were acquired through past experiences of the individual and the species. It is this ontogenetically and philogenetically acquired system of values that commands central sympathetic arousal to "translate" a particular configuration of signs—the pretext—into another sign system, the context of experienced meaning.

We may categorize the experience of meaning as another *sensation*, such as light, sound, taste,[2] pain and pleasure, and contrast—for example, the experience of light—as an externally induced sensation. If meaning is a sensation, then it should follow Fechner's law: with arousal rising in geometric proportion, the experience of meaning should be intensified in arithmetic proportion.

Having discussed the sign system of information and its arousal-induced translation into the sign system (or sensation?) of meaning, we may wonder about the relation of signs to neurobiology.

The creation of meaning and the hermeneutic circle

How are, for example, signs and action potentials from nerve related? Triggered by stimuli, action potentials from nerve are electric signals at recording electrodes. A logarithmic increase in stimulus intensity is generally paralleled by the action potential's increase in frequency. Although equal stimulus ratios produce equal sensory ratios, how sensation is related to frequency of nerve action potentials is an empirical question, even though in some

[2] The CNS does not differentiate between externally and internally induced sensations, and, accordingly, arousal (reticular activation or ergotropic arousal) should not only intensify the sensation of meaning but also sensations in other sensory modalities. This is indeed the case. To give an example: using a reproducible micro-method, we have found that at the peak of a psilocybin-induced arousal the just noticeable taste difference (jnd) decreases—i.e. fewer molecules of quinine, sucrose, etc. are needed to taste subsequent jnd-s—whereas tranquilization brings about an increase in the size of a jnd, that is, a decrease in taste acuity (Fischer, *et al.*, 1965; Fischer & Kaelbling, 1967; Fischer, *et al.*, 1969; Fischer, 1971b).

way sensation is caused by this activity (Gregory, 1981, p. 208).

Records of action potentials from nerve look all alike whether the nerve was stimulated by, i.e. interacted with, light, temperature, touch, tickle, chemicals... In order to know what kind of sensation a nerve is signalling we have to know the context, that is, where the nerve is located in the nervous system and/or the nature of the triggering stimuli. The brain, i.e. the CNS at large, signals with signs (recorded as action potentials) that become meaningful by being "translated into another system of signs" (Peirce, 1984; 4,536). Such translation, that is, the generation of meaning—conceptualized through arousal-driven oscillators—is hermeneutic interpretation that proceeds within the context of the very interaction that created it. Perhaps we have arrived here at the roots of the hermeneutic circle: the CNS legitimates reality, that is, the interpretation of its interactions, while the CNS itself is legitimated by the interpretation. The brain, indeed, is the only organ that learns to interpret its interactions as real by experiencing itself.

This same self-referential circularity is the essence of the "hermeneutic circle", that is a reflection of the self-programming brain-mind. To understand a text means to weave it into your own mode of existence (Corbin, 1957; p. 58).

The concept of the hermeneutic circle emerged in the third century when Origenes succeeded in interpreting the New Testament as a spiritual incarnation of the *logos*: a continuation and fulfillment of the Old Testament (Lubac, 1959; p. 305). Such treatment of the whole-part relationship in interpretation theory is embodied in the notion of the "hermeneutic circle"; individual features are intelligible in terms of the entire context, and the entire context becomes intelligible through the individual features in terms of the contribution they make to the meaning of the whole (Gadamer, 1960; Eagleton, 1983; p. 74). A Christian theological justification was to evolve from this approach: the Church could establish the right way of interpreting the Books—the right way being founded on tradition—but the tradition was represented by the very series of correct interpretations of the Holy Scriptures (Eco, 1984; p. 150). One may go even further back in tracing the origins of the hermeneutic circle and find it in Heraclitus, Parmenides, Socrates, Plato, Aristotle, Cicero, Quintilian, Celsus (the jurist), and later in Hegel, Fichte and Schelling. It crystallized in Frederick Ast, was developed by Schleiermacher and Dilthey; Freud extracted meaning from the context of (the details) of clinical material, and Heidegger expanded the hermeneutic (circular) method to all understanding. It seems only proper that the hermeneutic circle, having originated in rhetoric, having been enriched in interpretation theory, now returns to the promised land of its origin: neurobiology.

On the complementarity of excitation and expectation

The CNS at large (cerebrospinal-neural systems), i.e., the brain, is a closed synchronically functioning network that displays "*eigenbehavior*": a coherent pattern of relative activity dynamically maintained by indefinite recursion.[3] Indefinite recursion plays also a central role in computer theory, when, for example, *eigenbehaviors* arise (as fixed points) in the semantics of computer programs (Varela, 1977).

A basic feature of the brain—as well as the mind that it generates—is the recursive and simultaneous interdependence of its variables. Such interdependence enables brain-mind to counteract and to compensate for environmental perturbations. Perception of entities emerges—according to von Foerster (1981)—from iterating *eigenfunctions* at several levels of central cortical activity and objects are tokens for cognitive *eigenbehavior*. These tokens reside (are not localized) in the subject's experience of sensory-motor co-ordination (closure). The state of neural activity that specifies the motor event—as, for example, in "accomodation"—serves to determine the perceptual effectiveness of the sensory process, resulting in "size-constancy", that is, an invariance (Varela, 1979). The system (brain-mind), in fact, is in charge of maintaining a steady state between organism and environmental perturbations: invariants (dimensionless

[3] By recursion we mean that at a certain point of a process or processing the medium becomes the message, as for example in "this sentence has thirty-three letters". "thirty-three" is one of the *eigenvalues* expressing the identity of what the sentence is and what it says (von Foerster, 1981; p. 274 e 278).

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information ratios) are "markers" of this steady state.

The brain is organized hierarchically and represents sensory, motor invariants in a parallel manner, but there is a distinction between the cortex—concerned with invariants—and the cerebellum that handles variance. Such sharp distinction calls for fundamentally different representational strategies (Ballard, 1986). Neural processing times are only about one hundred times as fast as the fastest response times for complex sensory-motor closures ("tokens" or objects). This in itself implies that the cortex performs a massive amount of parallel processing. Such massive parallelism is required for an organism to achieve response latencies in the hundreds of milliseconds from processing elements (neurons) that operate from 100 Hz to 1Khz (Landy, 1986).

But the function of the cortex is not just the processing of invariants; it also represents particular values of invariant parameters, and hierarchies are a necessary organization in a "connectionist architecture" to process successively more invariant parameters (Ballard, 1986).

Let us place now within the above context the forceful and clear argument of Powers (1973): we know nothing of our own behavior but the feedback effects of our own outputs: "to behave is to control (what is sensed as) perception or input". But what is an input? What our muscles react to, for example, is not the stimulus but the difference between stimulus-induced feedback effect and the stimulus, while behavior intends to reduce this difference to zero (Powers, 1973). In kinesthetic feedback, to give a specific example (Don, 1976), nerve endings are excited by muscle contraction or their immediate effects on tissue or tendon. In the spinal cord, these *excitatory* signals are compared and subtracted from signals reflecting *expectations*—based on past experience—that issue from higher centers of the nervous system; then, the difference, that is, the error signal, is delivered to the muscle. Hence, zero error implies that the *excitation*, evoked by an environmental perturbation, that is, the actual path of a movement, coincides with the *expected*, and thus preferred path.

Let us listen now to the transliteration of this "inferential reconstruction" process in the language of psychology. Pre-conscious processes rank-order the sensory input and feed forward into conscious processes inspecting only those sensory data that are relevant to the implied behavior. Cognition or recognition is the process of inspection of this restricted set of sensory data and rehearsal of its behavioral consequences (Wall, 1974). All data, therefore, that are not available for conscious inspection will be *repressed*, denied, or misperceived. Only those perceptions will become accessible for which there exists a corresponding "expectant action" in the organism's interpretative repertoire that is appropriate for sensory-motor closure. Sensory-motor closure, should not, however, be regarded as just a precondition for perception (of objects) to occur; perception *is* embodied in the sensory-motor closure.

What happens to perceptions for which there is no appropriate "expectant action" in the interpretative repertoire? There is a temporal "detachment" of mind function (perception-behavior) from brain function—as measured by the "readiness potential"—or in Libet's (1981) words "there is a substantial delay or approximately 500 msec. before cerebral activities initiated by a sensory stimulus...elicit any resulting conscious experience". The subjective timing of the experience is then referred backwards in time (antedated), and its timing experienced with no delay. Conscious intent still precedes the (motor) act of behavior by about 200 msec. (Libet, 1985), and hence there is sufficient time for self-deceptive repression (Winson, 1984; p. 234).

Self-deception appears to be an integral part of the behavioral control of perception, i.e. the effort to have the world adapt to our capabilities, and, in this sense, self-deception has proven to have survival value.[4] We are selectively "information tight", that is, open to energy but selectively closed to external information (Ashby, 1956), ("selective", being my specification). What is the operational meaning of "selectively closed"? It refers to selection

[4] Self-deception is not restricted to "entities" and "data" that constitute the perceptual-cognitive "text of everyday life" (an expression coined by Schrag, 1980). Creating a text of narrative fiction also requires an act of suppression in order to come into being. Both the text of everyday life and the text of narrative fiction reflect the analogical relation between the structure of the narrator's brain and that of the narrative. Creation of both kinds of texts requires the self-deceptive practice of repression, denial and misperception. What both texts say is based upon what their author had to suppress in order to say (and see) it.

processes based on philogenic and ontogenic functional principles of the CNS at large (cerebrospinal-neural systems) that enables an appropriate limitation on (what is sensed as) "information input". Specifically, the input of the peripheral sensory receptors is reduced from 10^9 bits to 1-50 bits per second in central conscious processing (Kugler, 1981). Is this cybernetic repression "separate but equal" to or only part of the Freudian repression into the unconscious?

Originally the term "unconscious" was used as an adjective, and only later did it become autonomous as a noun. In Freud's view the unconscious is primitive, savage, childish (regressive) and wishful; it is also polymorphously sexual. Taylor (1966) also notes that the more normal the mind the less either the "subconscious" or the conscious is a separate unit; the more accessible the subconscious is to the conscious and the more the whole mind is integrated and integrative and thus creative. A distinction between the unconscious and the subconscious is made by Levi-Strauss (1958; p. 224-5), a distinction not to be found before the 1940's. The subconscious refers to memories that are retained but not always available. The unconscious on the other hand is as much a stranger to images as is the stomach to the food that passes through it. One could therefore say that the subconscious is the individual lexicon with individually accumulated vocabulary but the latter acquires signification in so far as the unconscious organizes it according to its own laws: thus making a discourse out of it (Wilden, 1968). Hence, for Lacan (1977), the unconscious is structured like a language.

That unconscious neuronal activity is constantly at work during movement (you do not have to watch your steps while running down the stairs!) seems well recognized. What is less well known is that probably most neuronal transactions are unconscious processes (Doty, 1969), such as cerebellar activity, neuronal discharge during most of the night's sleep, hormonal release, and, a most intriguing form of visuo-motor control, that is, *counteradaptation* to optically induced distortions.

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Perceptions as interpreted sensations.
The hermeneutic circle of self-interpretation

> ...there is nothing "more pleasant, or more instructive, than to compare experience with expectations, or to register from time to time the difference between idea and reality. It is by this kind of observation that we grow daily less liable to be disappointed". (Dr. Johnson)

We shall devote now some space and time to the *counteradaptation* phenomenon since it lends itself to a clear illustration. of the difference between *brain* function (resulting in an optically distorted image on the subcortical retina) and visuo-cortical *mind* function that also involves feedback from head and limb movement, thus correcting the retinal distortions according to expectations (intentionality!) anchored in past experience. Counteradaptation also illuminates the complementary equivalence between excitation and expectation in a most important sensory modality, vision, that depends on a larger neural network than do the other senses. And lastly, counteradaptation convincingly proves our claim that the mind *is* the behavior, that is, in this particular case, counteradaptive behavior, and supports the definition of perception, put forward by Freeman (1981, p. 578), as "the integration of sensory impressions...as a function of expectation...and (expectant) action."

The behavioral control of perception, that is, the complementary role of *excitation* (i.e., presentation of environmental perturbation) and *expectation* (hermeneutic pre-understanding) may be easily demonstrated with subjects who are exposed to optically distorted presentations of the world (see, e.g. Dolezal, 1982). How does a subject counteract and compensate for environmental distortions, or—in other words—is the difference between excitation and expectation reduced to zero?

It is well known that wearing distorting prism spectacles results in visual distortions that gradually disappear—i.e. the distortions are *repressed* and re-thought (visual-cortically), and after some time the world is seen again "as it should be", in accordance with one's goal-directed expectations (based on past experience), and in spite of the persisting distorted image of the world on the (subcortical) retina (Stratton, 1897; Kohler, 1964; Fischer, 1969; Hill & Fischer, 1970; Fischer & Hill, 1971).

The re-thinking or "counteradaptation" according to one's expectations may be conceptualized as a new coordination of object-directed movement of head and limb. Information *about* the executed movement (re-afferent information) must be systematically correlated with the *movement* (Mikaelis & Malatesta, 1974). Moreover, counteradaptation occurs only when the subject is actively moving around while wearing the distorting prisms (Held, 1965). Passive subjects do not counteradapt. To prove this point, Held designed an experiment with two subjects; one was walking around in the laboratory on his own, while the other was taken around in a wheelchair. In a further refinement of the design: the active subject had to push the wheelchair of the passive subject. Under these conditions only the active subject was able to achieve complete counteradaptation and see the laboratory undistorted (Jeannerod, 1985; p. 137). The phenomenon of counteradaptation, of course, cannot be localized in either the sensory or the respective motor systems; it is inherent in the sensory motor closure.

The image on the subcortical retina is usually conceived as a photograph-like rendering of environmental, i.e., excitatory perturbations, the retinal image being constrained by the shape of the lens and the refractor properties of light. Then, the visual cortex takes over and *expectations* based on past experience are integrated with re-afferent information from head and limb movement, and counteradaptation results as a coordinate transformation process. Now the difference between excitation and expectation may be reduced to zero.

The coordinate transformation are conceptualized by Pellionisz (1986) as sensory-motor transformations through neuronal networks in multidimensional vector space. Neuronal networks, such as loops and reflexes, are regarded as tensors, and sensory information is resolved into *covariant* vectorial components, while motor execution is composed of *contravariant* components. The coordination is a geometrical transformation of the motor vector from covariant to contravariant expression; the first features intention, the latter allows for execution. The scheme is a unification of the notion of temporal lookahead by Taylor expansion and the notion of cerebellar function as a metric tensor. The covariant distributed space-time components are first extrapolated by a lookahead and then transformed by the space-time metric tensor (Pellionisz and Llinas, 1979, 1980). This is a neocortical operation, a re-thinking *geometrico modo* that links the onlooker to a stage that it creates.

Such re-thinking—an unconscious learning process, according to Kohler (1964)—may well be regarded as an attempt at forcing the visual world ("as it has been, and hence, as it should be") to adapt to an organism that is confronted with the task of achieving sensory-motor closures, in a topsy-turvy world. By transforming the set of excitation to that of the expectation, the difference between the two sets is being reduced to zero and a steady state between organism and environmental perturbation is established. Kohler, for example, was capable of using pick and axe when mountain climbing in the Innsbruck area while wearing distorting prism spectacles; and Dolezal (1982, p. 297) had to put on an eight-pound counterbalanced football helmet to support his spectacles that gave him (continuously during a period of 15 days) the largest field of view in a mountainous Greek seaside town. Taking off the distorting spectacles results in suddenly seeing the distorted world that the spectacles *have been* projecting on to the retina (in-sight!). This latest set of "overcompensation" containing an unexpected world gone by, is gradually relinquished and, after a few hours of moving around, the familiar steady state between observer and his world is again re-established. The world continues now to be seen as it has been, and, as in fact, it is.

The visual cortical re-thinking of the prism-distorted world that prevails on the subcortical retina is a fast, continuous and *unconscious* sensory-motor learning. It results from a moving experience, or rather an experience of moving, and is reminiscent of the much slower sensory-motor learning of the infant.

The demarcation between what is accessible and what is inaccessible to consciousness is related to the difference between knowing *that* something is the case and knowing *how* to do something (Ryle, 1949). All learning depends on unconscious processes but this dependence is most marked in learning *how* to do things. Mountain climbing while wearing distorting prism spectacles is a skill that is comparable to learning how to improvise melodies to given harmonic sequences. Certain aspects of the improvisation are matters of conscious knowledge but most of the skill is acquired through unconscious learning to improvise while improvising. There would not be enough time for making conscious decisions about each note. Johnson-Laird (1983; p. 467) remarks that the fascination of improvisation is that musicians may surprise themselves by what they play. Evidently, what is going on is a very fast process that is inaccessible to the operating system. According to Johnson-Laird's computational hypothesis: any attempt to use introspection in order to become conscious of something that is normally unconscious is unlikely to succeed. Not only is the information inaccessible, but also an essentially *parallel* process has to be grasped by the *serial* deliberations of the operating system. The result is that the intrinsic nature of the process is distorted. We think of speech as an alphabet of sounds strung together like beads on a string; but there are no strings attached. We take categories and meanings to be invariably defined by necessary and sufficient conditions and hold inferences governed by mental rules of logic. But the structure of the concepts on which cognition depends is not open to conscious inspection.

Counteradaptive and cognitive performance during central sympathetic arousal

Let it be emphasized that sensory-motor coordination (closure or integration) is a *sine qua non* of the creation of perceptual objects whether they are real "tokens" or imaginary "objects" based on expectant behavior.

It is, however, arbitrary to detach the *conceptual* from the *perceptual* process. Conceptual (cognitive) factors are at least as important in maintaining the stability of the world, as exemplified by Wittreich's data, which show that an aniseikonic lens-induced distortion of the human figure is differentially resisted according to the degree of familiarity—or in our terms, hermeneutic pre-understanding—of the observer with the figure (Wittreich & Radcliffe, 1955; Wittreich 1961). Specifically, less distortion (more counteradaptive behavior), was always reported in a spouse than in a stranger; less in a mutilated than in a normal figure; and navy recruits reported less distortion of authority figures than of non-authorities. Children describe less distortion in a parent than in a stranger and, most important of all, the younger the child, the less developed is his ability to counteradapt to distortions, an observation that emphasizes the gradually learned perceptual-cognitive nature of invariants. Even phantom sensations, which are counteradaptation phenomena (Fischer, 1969), do not appear if amputation is performed before the age of four years (Simmel, 1962).

Counteradaptive behavior is evidently a skill that is gradually acquired by the developing child through sensory motor closures, that is, by touching things, moving toward or away from them, and by bumping into things. Counteradaptive skill is fully developed when the adolescent at last is clearly able to differentiate between objects in the world "out there" and him/herself. Prior to this stage the infant and the child live in a regressed state marked by what Freud (1938) labelled primary process thinking, a concrete, free-associative, drive-dominated, autistic state. When "normal" levels of arousal (that are associated with daily routine and characterized by rational secondary process thinking) are rising on the perception-hallucination continuum—or when arousal is lowered: on the perception-meditation continuum (Fischer, 1971a)—primary process thought becomes predominant. Regression in these hyper-and hypo-aroused non-ordinary states of consciousness may be measured by quantifying *primary process* thought content, and the ability to *counteradapt*. We have been measuring both parameters while inducing central arousal in college-age volunteers through the administration of hallucinogenic drugs of the LSD and psilocybin type.

Using the Regressive Imagery Dictionary, a content analysis coding scheme, that is implemented with a computer program called COUNT (Martindale, 1973), Martindale and I (1977) could show that 80-200 μg/kg of psilocybin-induced arousal significantly increases primary *process thinking and sterotypy* in texts written at the peak of the hallucinogenic experience. It was also found that the pattern of increase in primary process content is isomorphic with that of literary narratives (Martindale, 1975) describing a journey to and return from hell or analogous fabulous destinations (first part of the *Divine Comedy*, Book VI of the *Aeneid, The Tibetan Book of the Dead*). This isomorphism lends some credence to the notion that such narratives may be symbolic accounts of non-ordinary states of consciousness that are induced by hallucinogenic drugs, like psilocybin.

The gradual increase in arousal-induced stereotypy could also be demonstrated by measuring another parameter in texts written by self-selected volunteers: the coordination/sub-ordination ratio. The rise of this ratio is indicative of increased simplification in syntactic structure (Fischer & Landon, 1972), and indeed, it was found that an increasingly simplified syntax is a characteristic of texts written during increasing levels of arousal. Moreover, semantic orientation becomes more concrete, rhetorical structure is modified and the standard deviation on the numerical values of these parameters becomes smaller.

The increasing stereotypy can be thought of as an increasing *loss of freedom to verify* through willed motor acts, the intense sensations of the hallucinatory-regressed state (high sensory/motor ratio!). Increased stereotypy also signals a *gradual decrease in the ability* to cortically interpret (according to expectations based on past experience) the subcortical arousal. Specifically, particular levels of central, sympathetic arousal can only be interpreted as creative (artistic, scientific or religious), *psychotic*, or ecstatic experiences (Fischer, 1971a). It is irrelevant in this context whether these states are drug-induced or not; indeed, when representative parts of Walt Whitman's *Leaves of Grass*—conceived during what are today called "peak experiences"—are subjected to a linguistic analysis that was performed with texts written under psilocybin-induced arousal, and the texts are compared with one another, no fundamental difference is detectable between the language of creative performance and that of creative experience (Landon & Fischer, 1970).

Counteradaptive ability was quantified during drug-induced arousal by producing a distorting optical stimulus at a constant rate of 5 prism diopters (Δ) per second. This was made possible through an instrument that was outfitted with a pair of synchronously (motor-)driven counter-rotating prisms (Fischer & Hill, 1971). Through these prisms subjects were viewing (while immobile) a horizontal black line against a high-contrast white background. 15 student volunteers were tested under the influence of 160 μg/kg psilocybin at 60 minute intervals after drug administration (during a period of 4.5 hours). A mean Δ-value was computed at T_1, T_2, T_3 and T_4 from six determinations. The results demonstrate an arousal-induced significant lowering of the spatial distortion threshold (SDT), that is, the drug-induced arousal interferes with counteradaptation to optically induced distortions. Four Δ are required during the normal state of daily routine to just noticeably bend the horizontal black line, whereas at drug peak (T_5) only 2 Δ suffice to produce the same effect, that is, to lower the SDT. Or, to put it differently, at drug peak 2 Δ mark the diminished expectations; at this point the difference between visual cortical interpretation and subcortical (retinal) presentation or excitation is reduced to zero: the line is seen bent "as it is" (fact is more real than fiction!). During the normal state of daily routine, however, expectation of the straightness of the line to persevere (counteradaptation) is so strong (fiction is more real than facts) that it takes 4 Δ of distortion to bring the expectant visual cortical function to a halt, i.e. to stop the subject's hallucinating (a non-existing) straightness.

The observation that counteradaptation to optical distortions is diminished under hallucinogenic drug-induced arousal is not an isolated example. Phantom sensations after amputation—that is, distortions of the body image—are also diminished and alleviated (the amputated stump is seen and felt as it is) under the influence of another hallucinogenic drug, LSD (Kuromaru, 1962).

In the regressed state of hallucinogenic drug-induced arousal (a waking dream state of high sensory to motor ratio!) distorted reality is experienced "as it is": a line is seen as being bent; an amputated limb *is* missing. The normal state of daily routine, however, turns out to be a hallucinatory state of great expectations: lines are straightened out (although, in fact, they are bent, and amputated limbs are felt as if real (although they are only phantom sensations).

On some varieties of counteradaptive experience: prayer, placebo, and psychotherapy

The normal state of great expectations and intentionality, the daily routine of perceiving-re-cognizing, depend on correct interpretations of "what there is". The acquisition of a meaningful interpretative repertoire, however, is not a given but a gradually developing process that involves years of experience.

When subjects born blind are operated on many years later and acquire sight, they fail to recognize objects familiar to them by touch. The first of these accounts appeared in 1728 in the *Philosophical Transactions* (Davis, 1960) by William R. Chesselden, a famous surgeon who performed the operation on a boy of 13-14 years. The boy in this account failed to recognize by sight his cat which he had known prior to the operation by touch. Upon seizing her, he said: "So, puss, I shall know you another time". Senden (1960), who collected a very large number of operated cases, concluded that visual perception of objects in space is a gradually acquired slow process, "built-up" over a considerable period of time. For many weeks and months after beginning to see, the person can only with the greatest difficulty distinguish between simple shapes such as a triangle and a square (Young, 1951), and it may take as long as a year or two until a person can clearly differentiate between a man and a tree.

Evidently, the capability to perceive is the result of a slow learning process that culminates in perceptual "knowing": an interpretive repertoire of expectations—a hermeneutic pre-understanding—that is essential for the interpretation of visual sensations and for counteradapting against optical distortions. The paradoxical twist of perception is hermeneutic and circular: one has to have definite expectations (based on past experience) in order to be able to perceive an excitatory perturbation, but at the same time one has to perceive in order to accumulate a repertoire of expectations (necessary for perception).

Or in the words of Krech (1932): "rabbits test hypotheses", "rabbits smell what they expect, not what they sniff", "rabbits must learn to expect before they can perceive", etc. (quoted from Freeman, 1981). The gap between uninterpreted sensations and perceptions is filled with uncertainty and expectations.

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It is paradoxical that one must be uncertain about or question the existence of a phenomenon before one can perceive it...and at the same time one must perceive before being uncertain, remarks Norwich (1983) when generalizing the validity of Heisenberg's uncertainty principle and extending it from the subatomic level to all levels of perceptual experience.

Awareness, for Norwich, is not possible without uncertainty and one can (therefore) never perceive an event whose outcome is certain (this is the phenomenon of adaptation).

The uncertainty principle in perception or the complementary relation between expectation and excitation (presentation) are also at the root of our *conceptual* experiences (Fischer, 1985). The meaning of *parts* of a text for example, that is, the meaning of words and sentences, cannot be interpreted until one knows the meaning of the whole text...and one can only come to know the meaning of the whole text through understanding its parts. What you get out of a precept, a concept or a text will depend in large measure on what you put into them from your interpretative repertoire in the first place. That interpretative repertoire is commonly called "expectations" and refers to hermeneutic pre-understanding based on past experience.

The paradoxical situation implicit in our perceptual-conceptual mode of knowing reveals a neurobiological "control-system", i.e., a hermeneutic circle: individual features of the world become intelligible in terms of the whole context...while the entire context becomes intelligible through the individual features. This same circular and complementary relationship illuminates the interrelatedness of mind and brain: individual features of brain functions become intelligible through the mind...while the mind becomes intelligible through individual functions of the brain. Specifically, a reciprocal nesting makes the complementarity *simultaneously synchronous and recursively sequential.* The cybernetic concept and term "recursive complementarity" has been borrowed from Caley and Sewada (1986) to denote the emergent stabilization of brain-mind processes that are mutually interested. In paraphrasing Caley and Sowada and applying their concept we stipulate that the simultaneity of the synchronous and the sequential aspects of recursive complementarity arises in brain-mind from an interplay of interactions between negative feedback processes and positive feedback processes nested sequentially within each other in brain/space-mind/time.

Such hermeneutic, or circular, interpretation may become self-validating, and, in fact, may create the *interpretandum* it intended to explain. At times, we may no longer be able to distinguish between interpretations and what they are interpretations of. Hence, the circular relationship between *parts* and the *whole*, the feedback loop from *response* to *stimulus* (in a cybernetic control system), and the complementary relation between *excitation* and *expectation*, may be but attempts that alternatingly allude—within each pair—to interpretations as well as interpretanda. Nevertheless, each pair, in fact, refers to operational behavior. The complementary relation between excitation and expectation, for example, is operational not only on the neural-perceptual level, as in counteradaptation, but can be easily put to test in the behavioral domain through the power of prayer. Strong religious belief, and persistent prayer, in particular, may change what is a potentially stressful event. *Expectations* based on strong religious belief can alleviate or even inhibit the stress response, that is the process of adrenal cortical and medullary activation and reduce *excitation*, i.e. peripheral responsiveness to secreted noradrenaline (Benson, 1983).

Are the power of prayer, but also psychotherapy as well as the placebo effect varieties of counteradaptation? Very much so. And why is psychotherapy as effective as placebo treatment? Jerome Frank (1983) has a clear and precise answer: "With many patients the placebo condition contains the necessary and possibly sufficient ingredients for much of the beneficial effects of all forms of psychotherapy".

The necessary and possibly sufficient ingredients, such as faith, hope, trust, respect, and so forth..., belong to the category of *expectant behavior* (based on past experience), that is, a form of "knowing already there"—as in Plato's *Meno*—in short, hermeneutic pre-understanding necessary for self-interpretation. Expectant behavior is clearly a mind function that can re-direct certain brain functions. Through the varieties of counteradaptive behavior the mind is capable of overriding the brain, that is,—using Paul McLean's well known "triune brain" model—the neo-cortex is over-riding and harnessing the limbic system and the

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brain stem, i.e. the horse (and the crocodile) in us. This horse-cum-rider system, this "equimo" (from the first part of this essay), can perform more and better than either of its parts alone. The mind overriding the brain has its own mind. Living matter (the brain) is, in fact, re-directed by what it clearly directs (the mind).

It should be born in mind, however, that mind is not a localizable product of the brain (as urine is a product of the kidneys): mind is a production; it is intentional behavior subjectified in perception-cognition and objectified in sensory-motor closure.

Roland Fischer
(*Esporles, Majorca*)

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