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WHY THE MIND IS NOT IN THE HEAD BUT IN THE SOCIETY'S CONNECTIONIST NETWORK

Nothing seems more possible to me than that people some day will come to the definite opinion that there is no copy in the... nervous system which corresponds to a particular thought, or a particular idea, or memory.

Wittgenstein

In a recent essay* it was emphasized that brain and mind appear to the mind as complementary and reciprocally recursive domains of a hermeneutic circle (Fischer, 1987). An outstanding and not yet recognized feature of this hermeneutic circle is that interpretation within this circle is not rule-governed and hence appears

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self-organized: individual features of the world (or the brain) become intelligible in terms of the whole context (of the mind)... while the entire context becomes intelligible through individual features (or brain functions). How, or from where then is significance arising?

We can know but little of resemblance of our thoughts to the things (or the texts) to which we attach them: our beliefs about the underlying nature of the world are very likely inconsistent, to say the least. But the significance does not lie in the meaning sealed within things (or reading of texts) but in the fact that perception-cognition of things (or reading of texts) allows the emergence of meaning that had previously been sealed within our genetic and neural remembrance of things present. Meaning is not a static *signified* but refers to a distinctiveness admitting of an uncertainty and indeterminate articulation (Fischer, 1989). This contention may be applied, for example, to the psychoanalytic interpretation: if it is plausible, if it gives coherence to life that appeared chaotic and random, if—as Spence (1983) puts it—the analyst can find a meaningful ''narrative'' home for the awkward areas of the patient's experience, then (we may add) he has heightened his own awareness and enabled the patient to replace awkwardness with coherence and meaning.

We can go even one step further and compare a ''good model'' of an awkward problem in physics or in neurophysiology to a meaningful narrative home. A good model in physics, for example, participates in an unconscious interior organizing process (between mind and brain as well as reader and text), and is said to be explanative, according to Shaw (1984, p. 91), in terms of the subjective feeling of satisfaction it produces. Shaw, himself a physicist and mathematician, goes on to say that before subjective sensation is deemed out of place in a discussion of the construction of models, it should be remembered that such feelings or instincts guide all creative work, scientific or otherwise. A model can have ''explanative value'' even when it has no predictive power, the outstanding example being the theory of evolution, and—we may add—other *historical* processes, like learning, perception and hallucinations as well as dreaming (Fischer, 1989a). Understandably, the term ''history''—in most European languages—means both what really happened, and the narrative of those events. Events begin to be explained by being transformed into a story "by emplotment."

LEARNING-REMEMBERING IS NOT LOCALIZABLE IN SPACE

The inference that the remembrance of things (still) present (Fischer, 1975, and 1986) must involve time patterns is based on the observation that memory is not localized in space. Localization is restricted to the output channels, where each motor nerve carries commands to a particular muscle. But along the ascending nervous pathways through which information passes from the sense organs to the cerebral cortex, localization becomes increasingly diffuse at each synaptic layer, so that finally a very large number of cortical neurons are influenced by a message in any given sensory channel. Again on the output side, the further back one goes in the motor pathways, the more does any local excitation produce output in several muscles. Pringle (1976) reminds us in this context that large areas of the human cerebral cortex—called by Penfield the uncommitted cortex—have no function that can be defined in terms of localized effects, and hence information has to be transformed into patterns in time rather than space (and back into spatial patterns on the way out again). Indeed, in human cases where electrical stimulation of the cortex appears to elicit specific memories, extirpation of the stimulated area does not affect recall of this memory (Penfield & Perot, 1963).

The transformation of messages from time into space and *vice versa* is feasible since space and time are "equivalent", an observation that can be impressively illustrated by the Pulfrich phenomenon (Fischer, 1966 and 1977). A steel ball is suspended as a pendulum moving along a horizontal plane, that is, swinging from left to right. If the observer holds a smoked glass before only one eye, the horizontal movements of the pendulum are transformed into elliptoid movements in space. The time difference in nervous transmission that is produced by reducing the stimulus intensity (through the smoked glass) is being translated into a space difference. Specifically, each log unit reduction of intensity results in about 10 msec. delay in the transmission of visual stimuli. Increasing the time delay transforms at last the elliptoid movements of the pendulum into circular movements. Moreover, placing a filter over the other eye reverses the direction of the elliptoid motion. Thus, differences in intensity of stimuli and/or temporal differences between stimuli determine the localization of visual, tactual, temperature, auditory, gustatory, olfactory or a combination of gustatory and olfactory phenomena in space. By varying the time delay, for example, between the presentation of a gustatory and olfactory stimulus, it is possible to make the combined sensation move from the tip of the nose back to the throat and then again forward to the tip of the tongue (von Békésy, 1964).

Another manifestation of the equivalence of space and time is the systematic shift in experienced time of subjects observing differently scaled environments; E = x (T), where E = experienced time, x = reciprocal of spatial scale, and T = clock time (De Long, 1981). Reduction of the spatial scale results in *chronodiastole* or expansion of experienced time.

The equivalence of biological space and time bears a striking resemblance to the equivalence of space and time in physics. An essential difference between them is that the universal constant for the former is the speed of light at an assumed 300,000 km/sec., and, for the latter, the conduction velocity for impulses traveling along nerve fibers varies from 1 to 100 msec. in inverse proportion to the diameter of the fiber. Moreover, in biological space-time differences in intensity of stimuli are transformed by the nervous system to frequencies which are proportional to the logarithm of the intensity of the stimuli.[1]

Space-time equivalence may be a perceptual manifestation of the complementary, feedback-assisted integration between the two cortical hemispheres, the right hemisphere presenting the world as patterns in space, and the left presenting the world as a sequential "text" in time.

[1] Zabara (1973) ponders the difference in the units of operation between the (Newtonian) physical universe and the nervous system. The unit of operation in the former is matter (a body of it, or, if it is sufficiently small, a particle), whereas in the nervous system it is the "pulse" (that, like matter, is a primitive, undefined term). Both matter and pulse have certain perceptible properties; matter has "substance", "inertia" and "extension"; the properties of the pulse are "conduction" and "all or none". Matter's axioms of operation are described by Newton's three Laws. The

Space and time may be cerebral constructs that are built up little by little, according to Piaget (1954) and, indeed, Berkowitz and Tschirgi (1988) argue that the human conceives himself to be embedded in three-space not because the "world out there" is intrinsically three-dimensional, but because the human nervous system is functionally asymmetric in three dimensions. Concomitant with the evolution of multicellular organisms as expressed in the progression of asymmetry in external body form and spatial function—from spherical symmetry, through radial and bilateral, to (cerebral) asymmetry in humans—the number of spatial dimensions in the world apparently has evolved from zero to three.

Given the critical significance of simultaneity for the development of *temporality*, perhaps the neurophysiological and experiential reference frames have fundamentally different forms of temporality associated with them, claims Snyder (1988), whose contention is based on the curious results of Libet *et al.* (1985). These data reveal that the onset of the physical stimulation associated with a peripheral sensation and the *experience* of this sensation are approximately simultaneous events, whereas the onset of the physical stimulation associated with the peripheral sensation and the *achievement of cerebral neuronal adequacy* are not. The assumed antedating, or delay is, of course, reminiscent of the phenomenon of space-time equivalence.

If space is a biological construct, and time is equivalent with space, then it is very likely that time—the sequential perception of data and their fusion within a restricted frequency range into simultaneity—is also a biological construct. Be that as it may, a philosopher to whom Libet's experimental data were described said wryly that the implication was clear: "our brains have free will but we don't".

major difference, however, between the physical universe and the biological universe of the nervous system is the axiom of operation: whereas matter displays rectilinear motion, the pulse has circular motion. With all these differences in mind Zabara concludes that the physical universe can be considered as a special case of the operations of the nervous system.—How did G. K. Chesterton phrase it? "The cosmos is about the smallest hole that a man can hide his head in."

Localization as Fact and Fiction

The dispute between the two main schools, the localizers, that is, the Geschwind-Luria school, and the "systemic" non-localizers, that is, the Jackson-Head-Bay school, may be attributed to their interest in different subject groups, notes Gardner (1974). Localizers tend to focus on older subjects, where fixed lesions produce permanent impairment; antilocalizers concentrate on young subjects who recover impressively, independently of the locus, and even the size of the lesion. But all generalizations falter when it comes to left-handed persons—about ten percent of the population. Approximately half of the left-handers have their speech area represented not on the left side of their cerebral cortex—like right-handers—but wholly or in part in the right cerebral hemisphere.

Broca, (1865; p. 383) of course, never claimed "cerebral dominance" for language. He isolated only the speech *production* aspect of language by a localized lesion (Eling, 1985). Interestingly, a gradually expanding lesion, like a tumor, will, however, not result in aphasia, even when the tumor is in the speech area. It is the sudden interference in one step which is crucial in producing a behavioral deficit since lesions produced step by step, *i.e.*, in stages, do not cause appreciable deficit (Lenneberg, 1972). It is also puzzling that a map showing localized brain functions based on electroencephalography (EEG) does not match the localized functions mapped on the basis of specific brain lesions.

Perhaps 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 may be conceptualized as being in dynamic equilibrium with phenomena of the world through self-knowing (of the mind), that is, thinking. Perceptual-cognitive problem-solving or interpretative operations, therefore, including aesthetic experiences, may be definite states of equilibria[2] that produce satisfaction: terminal unity of opera-

[2] For Mondrian the aesthetic feeling is the harmonious balance of opposites in a differentiated, hierarchical whole. (Compare this with Lévi-Strauss for whom think-

tions 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, nevertheless 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.

Hence, electroencephalographers are, in fact, archaeologists of the mind, and their data represent—the "archaeology of knowledge" (Foucault, 1972).

Is this knowledge localized in the brain? In *The Interpretation of Dreams* (1900) Freud rejects the notion that it is possible to assign anatomical location to mental processes, or that they need to correspond to any physical structure.

> I propose simply to follow the suggestion that we should picture the instrument which carries out our mental functions as resembling a compound microscope or a photographic apparatus, or something of the kind. On that basis, psychical locality will correspond to a point inside the apparatus at which one of the preliminary stages of an image comes into being. In the microscope and telescope, as we know, these occur in part at ideal points, regions in which no tangible component of the apparatus is situated...

Indeed, localization of function is surprisingly difficult to comprehend or establish even in simple machines, remarks Gregory (1981).

ing proceeds in binary oppositions). In painting this "*dynamic equilibrium*" of opposing elements is expressed by the right angle (Mondrian, 1945) and wholeness can only materialize by eradicating mimetic relations, which, being intrinsically bound up with desire, create disequilibrium and tragic disorder (Butler, 1982). The dominant aesthetic impression is spiritual *repose*. "Repose becomes plastically visible through the harmony of relations"—these being of three kinds: relations of position, relations of proportion and relations of colour. Mondrian confines his aim to the expression of the constants (or invariants) of the human mind; bands cut or intersect through rectangles and through the thickness of lines; the right angle and the parallels: "relations of position"; simple divisions and the golden number: "relations of

> The trouble is that disturbing a mechanism or an electronic circuit, by removing or changing characteristics of components, generally affects the mechanism or circuit in strange ways, which themselves need explaining. It is now a different system, with different properties; to understand these the entire new system may have to be redescribed. For example, a small change in an amplifier can turn it into an oscillator... There are further problems when there is redundancy, for then nothing may happen when parts are removed.

Karl Lashley (1950) also comes to the conclusion that mental functions, like memory, have to be distributed in the central nervous system (CNS).

> It is not possible to demonstrate the isolated localization of a memory trace anywhere within the nervous system... The same neurons which retain the memory traces of one experience must also participate in countless other activities... Recall involves the synergic action of some sort of resonance among a very large number of neurons.

Ten Houten (1978) is correct therefore when he formulates the problem as follows:

> In spite of the vast accumulation of evidence that the left and right cerebral hemispheres are specialized for different types of information processing, it is still not known how thoughts are produced by the brain. Unfortunately, complains Semmes (1968), the concept of cerebral lateralization ... proposes nothing ... more than a label, a restatement of the finding that lesions of one hemisphere produce deficits that lesions of the other hemisphere do not.

proportions''; discrete and sonorous harmonies of unshaded tones: ''relations of colour'' (Bouleau, 1963).

What matters is to create a superior beauty through rigid mathematics (beauty that is devoid of any subject matter), a pure work of art, that is, the onlooker's own neuronal firing pattern (in time) as it reflects itself in the mirror of its recursive function(ing). That function(ing) is a contemplating vision of space as relations of position, relations of proportions, and relations of colour.

In spite of the current distinction between abstract and figurative art, it is becoming apparent that at all times painters were not only painting but also constructing while painting; giving organization to forms and harmony to lines. Working in the West under the constraint of the frame and of symmetry painters nevertheless were using subject matter as a pretext rather—forced upon them through the social reality of their era—a pretext enabling them to stand in front of their own neuronal firing line: carefully considering the geometry of positions, proportions and colour.

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Left-right distinctions such as analytic *vs. gestalt*, serial *vs.* parallel processing, similarity *vs.* dissimilarity judgements may reflect but an innate dichotomizing function of the mind. Such a property that dichotomizes in terms of binary oppositions may be important for purposes of survival (conceiving "research strategies" under "extreme conditions"). Binary oppositions, Aristotelean or two-valued logic, and cause-effect relationships have been and still are important tools when coping with a threatening and incomprehensible world. It is rewarding to observe how the tendency to dichotomize is colored by the *Zeitgeist*, that is, fashionable biases or the social reality of a particular era. 19th-century dichotomies, for example, reflect the inferior status bestowed on women, nonwhites, animals and the insane, while right-hemisphere values in the 20th century owe at least something to black power, women's liberation, the protest against the Vietnam war, the rise of the industrial-military complex, and the increasing popularity of Eastern religious cults (Corballis 1985).

In concluding this section, let me recall that in all twinbrained species, that is, in all vertebrates an inhibitory mechanism prevents each half brain from having introspective access to the conscious content of the other to prevent, for example, a doubling of the visual field (Pucetti, 1985). Clearly, "I am not where I think, and I think where I am not" (Lacan, 1977).

In summary: the two decisive arguments against localization are based on (1) Lashley's evidence that the deleterious effects of removing parts of the cerebral cortex depend on the *amount* of tissue removed but not on its exact location, a finding that led to the principles of mass action and equipotentiality, and (2) the well established fact that sensory and motor systems have *multiple* representations (brain maps). In other words, although everything is represented everywhere, some functions are represented at certain points more than others. For example, the retina is mapped over and over in the cortex; the cat has at least thirteen mapped representations of the retina, the owl monkey at least eight, and so on. Their existence throws light on what is seen now as an unwarranted controversy about localization of function. Cortical events underlying *complex and cognitive functions* are so widely distributed that no brain damage, however great, can either destroy them entirely or leave them wholly unimpaired

(Gregory, 1987, p. 438). With reference to intrahemispheric localization of function: there is an abundance of provocative data and of ingenious tricks for investigating the brain, but exactly what it all means in terms of definable capacities remains deeply puzzling, concludes Churchland (1986, pp. 193-202), and goes on to say, that even the claim that Broca's area is responsible for speech and Wernicke's area is responsible for comprehension, is an oversimplification.

A Hermeneutic Circle: Expectations are Based on Perceptions that are Based on Expectations

"Localization" refers to lesions and their consequences but not to "centers" in charge of specific "functions". Gregory (1981) puts it succintly and with a touch of irony:

> Just because your radio emits a howl when you remove a transistor, you are not justified in calling the removed part a "howl-squelching center."

Our vocabulary suggests a variety of conceptually separate higher mental faculties as, for example, "to learn" "to perceive," "to recall," "to predict," "to remember,", etc.; and the attempt is made to identify and to localize within the various parts of our brain the functions or mechanisms that learn, perceive, recall, predict and remember, and so forth. This hopeless search for mechanisms that represent these functions in isolation does not have a physiological basis but a purely semantic one. In separating these functions from the totality of cognitive processes, one abandons the original problem and searches for mechanisms that implement entirely different functions. To understand these an entire new system would have to be redescribed.

"Where is (altruistic) behavior stored in a sperm or ovum?", is as good a question as "where is memory stored?" When an organism is eating, where is its mating behavior? Is it in storage? If it is idle to talk about our "sexual reservoir" which "stores mating" while we read or eat, then it is idle to talk about a reservoir that stores words or images (Peat, 1976).

Memory is not the recalling of the past but an inferential reconstruction of a "present that never keeps passing" (Paz, 1949). Inferential reconstruction is a creative act based on past ("learned") experience, a *cognitive-perceptual* process that guarantees the continuity of both experience and experiencer. If past events were localized in the brain as "engrams", we could recall them only as fragments or static still frames. Inferential reconstruction, however, is not a fragmented but a creative process that modifies past experience within a new (the present) context. In the same vein certain themes or "stories" are re-written, paintings re-painted, and music re-composed for each generation... in a way which revises, displaces and recasts past experiences. They are being re-arranged in accordance with fresh circumstances and become retranscriptions, that is, "the remembrance of things present" (Fischer, 1979).

When arguing in favour of a cognitive-perceptual process, we are in good company with Irving Rock (1982) for whom both perception and thought entail reasoning, and in some cases creative problem-solving. Rock claims that operations that culminate in perceptual experience are of the same kind that characterize thinking.

We should like to illustrate the claim of intelligent perception by comparing the cognitive-perceptual performance of two kins of subjects: those who were born blind but regained sight many years later (after cataract surgery, for example), and subjects wearing distorting prism spectacles.

The acquisition of an interpretative repertoire is a gradual process; without interpretation there is no re-cognition. When, for example, 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. Cheselden, a famous surgeon who performed the operation on a boy of 13-14 years. The boy in this account by sight failed to recognize 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 assembled 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 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 interpretative repertoire of expectations—a hermeneutic pre-understanding—that is essential for the interpretation of visual sensations. 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).

We come now to the subjects wearing distorting prism spectacles! They differ from the former subjects (born blind) in that they have accumulated since birth an interpretative (cognitive-perceptual) repertoire or hermeneutic pre-understanding, and it is almost miraculous how they put this repertoire to very good use, indeed.

How does a subject *counteradapt* and compensate for imposed distortions or, in other words, how is the difference between environmental *excitation* (resulting in a distorted world on the subcortical retina) and *expectations* (based on past experience) reduced to zero? (Fischer, 1987).

The topsy-turvy world produced by distorting prism spectacles gradually disappears—a visual-cortical rethinking of the distortions proceeds as an unconscious process, that is, a mind function—and 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 distortions on the subcortical retina, that is, a brain function (Stratton, 1897; Kohler, 1964; Fischer, 1969; Hill and Fischer, 1970; Fischer and 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* (Mikaelian and Malatesta, 1974). Moreover, counteradaptation occurs only when the subject is actively moving around while wearing 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[3] was able to achieve complete counteradaptation and see the laboratory undistorted (Jeannerod, 1985; p. 137). Counteradaption, of course, cannot be localized in either the sensory or respective motor systems; counteradaptation is a transformation as re-interpretation of sensory-motor closures in the light of past sensory-motor closures.

Removing the distorting prism spectacles results in suddenly seeing the distorted world that the spectacles have been projecting onto the retina (the actual present is temporarily inaccessible). This latest set of "overcompensation" containing a world gone by is gradually relinquished, and after a few hours of moving around, the familiar steady state between observer and his or her world is again re-established. The world continues now to be seen as it has been, and, as in fact, it is.

The behavior of both the formerly blind subjects and those wearing distorting prisms make us conclude: infants are not born, as Kant imagined, with *a priori* percepts and concepts (i.e. the Platonic "knowledge already there"); rather they are born with an innate ability to acquire them *a posteriori*.

Contrasting the perceptual capabilities of formerly blind subjects with those wearing distorting prisms leads to the inevitable generalization that (re-)cognition-perception is *one* mind-function

[3] In a study involving a partial replication of an experiment by Held & Rekosh (1963) that dealt with the role of visuo-motor feedback on prism-induced changes Gyr, Willey & Henry (1979) could not replicate data supporting the importance of active *vs.* passive visuo-motor feedback. A close reading of the Open Peer Commentary (*ibidem*, pp. 64-86) comparing the two sets of experiments reveals, however, that the stimulus-environment and instructions used in the studies were different; not to mention a significant difference in method. Moreover, Gyr *et. al.* did not use an optimal situation for curvature adaptation and were unable to find adaptation with either their sub-optimal approach or with the traditional prism-base orientation.

that is, to a large extent, a learned and subconscious process. Moreover, this interpreting function is distributed over the whole body of a person, and, even over the body of the society that raises, tames and contains the individual within the confines of his or her genetic program. Counteradaptation is not localized in and restricted to the brain: movements of head and limb (with their afferent as well as reafferent information) are essential parts of counteradaptive behavior as it emerges as an inferential reconstruction process.

We may subdivide re-cognition into a "yes-no" mode for the re-cognition of objects, and a "continuity-conferring" mode that enables us to recognize tunes, faces... and our own place within a variety of larger contexts (being a male, a father, a soldier, taxpayer, and so forth).

Freud (1900) wrote in the final chapter of *The Interpretation of Dreams* that

> there are obvious difficulties involved in supposing that one and the same system can accurately retain modifications of its elements and yet remain perpetually open to the reception of fresh occasions for modification... [Therefore] we shall distribute these two functions onto different systems.

Harnad (1982) also ponders the differences between what he describes as *bounded* or computable engrams (for absolute discrimination) and another unbounded species of representational system that may consist of analogues of instant-to-instant experiences ... and then, goes on to say:

> It would seem that if *ab ovo* I am reducing and quantizing and ignoring as I learn, the world should be getting steadily more and more fragmented... And yet my experience seems to be, and always to have been, uniformly and continuously whole for as long as I can recall! Is that sense of "recall" a contradiction in terms?

Evidently, we are dealing with "inferential reconstruction" but encounter difficulties in inferring how the reconstruction process is generated. The physical basis of memory remains a mystery, comments Gregory (1981; p. 294). Memory and awareness in complex neural systems may depend upon presently unrecognized properties of the system as a whole, and not upon any of the elements that constitute the system (John, *et. al.*, 1986), but, in any case, the relevant unit (in the brain) is the neuronal population rather than the individual neuron (Georgopoulos, Schwartz & Kettner, 1986).

The basic hardware of the brain functions some 10^6 times slower than that of serial computers, and this fact in itself prompts the inference that brain function results from the cooperative activity of very many processing units (*distributed* neuronal assemblies) operating *in parallel* (Rumelhart, McClelland, *et al.*, 1986; Vol. 1, pp. 130-1). On the other hand, few neural models are capable of dealing with the transition from parallel processing, to serial computation. The method for accomplishing this—the homunculus that looks at the results of parallel processing—is as unobvious now as it was for more classical neural models (Landy, 1986; p. 102). When looking at a sculpture on a TV-screen, for example, there is a serial representation from the sculpture to the TV-screen, and a parallel processing type representation from the TV-screen to the retina, remarks Pellionisz (1986), and it is perhaps possible—he continues—that from the retina to the visual cortex there may be yet another type of representation. It is important at this juncture to clearly state that there is no computing going on in the brain. To assert that the brain or any part of it *computes* carries as much meaning as saying that a telescope computes the trajectories of light rays passing through it (Hart, 1986).

ON ENGRAMS PENFIELD HAD IN MIND

The California-based *Brain Mind Bulletin*, when reviewing Wilder Penfield's *The Mystery of the Mind* (Schuman, 1976), gives a fair account of the engram-story, "the only question that counts". The review reflects a generally prevailing, an almost popular opinion: memories are encoded as engrams

> at certain sites of the brain's [exposed] temporal lobe ... and stimulation (with an alternating current flowing through a small silver ball electrode) produced a 'flashback', a dreamlike episode in which the [epileptic] patient re-experienced the stream of consciousness of an earlier time as though watching a movie of the past.

The description refers to the original paper of Penfield and Perot (1963), an extensive report of observations of such stimulations in a series of 1132 cases during the period 1934 to 1961. The *experiential responses*, as Penfield has named them, consisted of "reproductions of past experience" of individual memories. Such responses have been observed in only 40 (3.5%) of the 1132 cases and it has been the right nonverbal hemisphere that yielded most of these responses.

Penfield believed that "in the vast circuitry of the human brain the evidence of an engram, a recording of succeeding states of consciousness, is clear." When he re-stimulated the same point after a few seconds, the same experience was usually repeated. But how can the hand that holds the electrode locate the same point again? Horowitz, *et al.*, (1968) implanted depth electrodes in 16 patients with intractable temporal lobe epilepsy; but no two stimulations of the same anatomical point produced the same hallucinations. Moreover, the same authors reported that "the hallucinatory experiences could be shown often to relate to the patient's mental content before the stimulation," and that the "relationship between the prestimulation mental content and the sensory experience resembled the processes of dream construction." Displacement, distortion and condensation were observed and a state of consciousness that can be characterized by a prevalence of primary-process cognition.

Birchmeier-Nussbaumer (1974) requested and obtained from Penfield the original reports that were recorded from the 40 patients of Penfield and Perot (1968) and subjected the texts to an object-oriented vocabulary analysis. She comes—independently—to the same conclusion as Horowitz and his associates (1968), namely, that the common set and setting shared by all patients before and during the operation is reflected "in the majority of the texts" ... in the form of well defined clusters of words "that center around particular meanings." Birchmeier-Nussbaumer points to a considerable number of associative links between the stimulation vocabulary and the common set and setting shared by the patients. Her results also compare well with the findings of Klinger (1978-1979): healthy subjects rate 66 per cent of their thoughts as related to attentiveness to external cues, a figure very close to the independent estimates of outside judges (69 per cent).

Hence 66-69 per cent of the thoughts are semantically related to the participant's settings or activities at the time of the thought. Clearly, both the epileptic patients in the pioneering study of Penfield and Perot (1963) and those of the well-controlled research of Horowitz, *et. al.* (1968) report experiences in response to electric stimulation of their cortices, the thought content of which—in the majority of cases—is related to the common stage set and setting, the operating theatre. The patients behave like healthy subjects, whose thought content in the majority of cases is semantically related to the set and setting at the time of thought (Klinger, 1978-1979).

Hence Penfield and Perot's evaluation of their experiments was based on their expectations, *i.e.*, interpreted in the light of their localized engram hypothesis. No past experiences were evoked and, as the carefully controlled experiments of Horowitz, *et al.* (1968) clearly show, repeated stimulation at the same points of the temporal lobe (through implanted electrodes) could never elicit the same thought content twice.

Penfield (1958) was careful to remind us that the activation of mnemic engrams from the exposed cortex of the temporal lobe might be possible only in *epileptics* (since normative data were not available) and this, indeed, is the case. Ishibashi, *et al.* (1964) have stimulated both cortical and subcortical structures in chronic schizophrenics—but what they found were visual hallucinations in response to subcortical activation. And recently, Ojemann (1986) comes to the conclusion that the experiential phenomena described by Penfield occur with temporal lobe seizures and disappear after excision of the epileptic focus that renders the patient seizure-free. The electric activation procedure of Penfield is, to sum it up, an induction of "mini"-seizures. Ojeman's conclusions, however, do not answer the question: why did only 3.5 percent of Penfield's epileptic patients respond with "mini seizures" evoking dream fragments, or more precisely, flashbacks, in response to the induction of (high) levels of arousal that were associated with a particular (emotionally loaded) past experience? Could it be that the level of arousal induced was too low for 96.5 percent of the patient population? The administration of very low doses of hallucinogenic agents (in the range of 50 μg of LSD, or 7 mg of psilocybin) 45 minutes prior to electric stimulation could have raised the level of central arousal, and, accordingly, the number of patients experiencing flashbacks. Moreover, according to Creutzfeldt (1977), the function of any cortical area cannot be considered apart from its thalamo-cortical and cortico-thalamic connections. The same is true for any other cortico-fugal efferents, and it must be realized that any subjective experience during a localized abnormal excitation of a given cortical area (be it elicited by artificial electric stimulation or a focal epileptic discharge) does not, in itself, prove that this experience becomes conscious due to activation of the respective cortical neurons or of subcortical systems activated by these cortico-fugal efferents, or both. The dynamic localization of functions in the cerebral cortex calls for a radical revision of the concept of function ... of *what* it is that must be related to the structure of the brain (Luria, 1966).

Furthermore, in our era of parallel distributed processing (PDP), the historically dated concept of an engram has to be revised. PDP is embodied in the activity of large populations of neurons over time, a temporal feature rather than a spatially localized one.

Nevertheless, and in spite of the fact that the Penfield and Perot (1963) report of "reexperienced memories" elicited by brain stimulation could not be reproduced during the past quarter of century, it continues to be quoted in neurotourist's guides (to the perplexed) as a quasi-mythological text of unquestionable authority. Mandell (1980), for example, writes about "unrolling memories and the phenomena reported by Penfield (1955) as induced by electrical stimulation"; LeDoux (LeDoux & Hirst, 1986) refers to Penfield's report of "reexperienced memories" elicited by brain stimulation; Benzon and Hays (1988) quote Penfield "whose patients could be stimulated to reexperience [episodes] from their past"; and Honderich (1988) emphasizes that the same electrostimulation, if repeated, elicits the same recall-experience. And so on, and so forth...

Bridgeman (1987) politely and poignantly assesses the above paradoxical situation by concluding that neurobiologists and cognitive psychologists hold slightly outdated and distorted views of "the other field".

That counteradaptive behavior or the seeing of the optically distorted world as it should be, occurs only when the subject is actively moving around while wearing distorting prisms is an impressive illustration of the unity of perception and action. For Creutzfeldt (1979; p. 224), the various aspects of actions are contained in the input to all cortical areas, particularly in the spatio-temporal activation patterns of the motor areas, as functional transformations in terms of sensory input patterns in the sensory cortices; hence, the unity of perception and the unity of action are but two aspects of the same problem. Actions evolve over time—they take time— and so do perceptions. Thus, representations of the world in their various (co-ordinate) transformations from sensory maps into spatio-temporal action programmes are continuously changing from one moment to the next (while they are making time) and are completed only when the action is *passé*. Therefore, a given state of neuronal activity within the cortex, or, in fact, within the whole brain, represents only some of the necessary but not the sufficient "substrate" of perception or the "programme" of a motor performance. Only the relationship of the combined activities of individual elements of the network, *i.e.*, the *pattern over time*, describes the stimulation-event. Hence, trying to ascribe a physiological "substrate" to mind, or consciousness, is doomed to failure. The cortex is a functional link to but not the "seat" of "recognition", "decision-making", "programming" and whatever the terms may be that are used to entrust it with the "highest functions" of the nervous system (Creutzfeldt, 1978; p. 377). The actualization of perception-action or sensory-motor integration (or closure) is a production (of objects and/or their images) in the spatio-temporal domain.

The functional "specificities" of the various cortical areas lay in their distinctive connections with afferent projection systems and with efferent target structures; differences in mind function are not due to fundamental differences in morphology of the cortical areas. Widely distributed cell assemblies, that are distinguished rather by their neurochemical identity than by their morphological topography have been demonstrated by Hobson and associates, for example,—comments Jasper (1986)—to control cyclic changes in states of sleep.

That mind-functions are non-localizable distributed productions observed-experienced as behavior was already hinted at by Descartes (1976; p. 62), who in a letter to Meysonnier, dated January 29, 1640, takes the view that memory traces may be located *throughout the brain* and even other parts of the *body*:

> ... for instance, the skill of the lute player is not only in his head but partly in the muscles of his hand, and so on. And we may add, that the lute player's skill, a mind function, is laid out (becomes audible and visible) in space and time as *lute playing behavior*; it is a production, that is, the actualization of the unity of perception and action.[4]

The unity of perception-cognition and action is also evident in the intriguing model that Pringle (1976) has suggested:

> ... the initial time pattern for any thought, the input channels which determine the conditions in which the temporal selection process takes place and the output channels through which the selected time patterns are re-expressed in spatially localized movements (thinking as a moving experience! [Fischer, 1986, pp. 3-5]) are all part of the given situation for any individual brain.

The Distinction Between Matter and Mind is a Matter of Mind

Let me re-phrase the initial question (in the subtitle of the very first section of this essay): Is mind a functional property of (brain)matter in the mind? Or, in other words, is the *distinction* drawn between mind and matter a functional property of mind? Yes, it appears so. For the observing mind there is only one type

[4] Another example that illuminates the unity of perception-(re-)cognition and action is handwriting. The oscillatory time pattern of the neural net, that is, thinking, reflects itself in the handwriting production, a sensory-motor closure (Fischer, Kappeler, Wisecup & Thatcher, 1971; Thatcher, Kappeler, Wisecup & Fischer, 1971), as constrained modulation of the underlying oscillatory process (Hollerbach, 1981).

Coupled oscillations in horizontal and vertical directions produce letter forms and when superimposed on a rightward constant velocity horizontal sweep result in spatially separated letters. Hollerbach developed an acceleration and position-measuring apparatus and finds human handwriting measurements consistent with the oscillaof knowledge, one that is always linked to the observer. And this observer is structured exactly like what he or she observes. Thus, the observer or *marker* of distinctions (in terms of binary oppositions) and the *mark* are not only interchangeable, but in the form identical (Spencer-Brown, 1969; p. 76).

This is not an entirely novel insight. Peirce's 1868 paper (1984; p. 241) already states that "the word or sign which man uses *is* the man himself" and that "the man and the external sign are identical in the same sense in which the word *homo* and *man* are identical. Thus my language is the sum total of myself, for man is the thought."

According to Peirce, the mind cannot be located in the individual organism. It has an "outreaching identity" in the processes of communication—verbal and non-verbal—and the "loosely compacted persons" who are both its agents and its products.

Peirce has prefigured (in general terms) our definition of mind as behavior: 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 (Fischer, 1987). Peirce has also prefigured the theory of "punctuated equilibria" by Eldredge and Gould (see: Eldredge, 1986), that regards species as individuals (in terms of information processing). The species alive at any one moment are the historical packages of available genetic information (outreaching identity) supplying both the players in the ecological arena (loosely compacted persons: *society*), *and* the very basis of all future evolution.

WHY THE MIND IS NOT IN THE HEAD

Are not "the loosely compacted persons" (of Peirce) the individual

tion theory. An oscillation-modulation scheme *reduces* the information-processing requirements for handwriting at the expense perhaps of letter shape diversity—ponders Hollerbach—and he speculates that such reduction is necessary for thinking and writing at the same time.

Anyone who has seen a chart of Lissajous figures will realize that limited modulations of the amplitudes, periods, and frequencies of two concurrent orthogonal oscillations can give rise to an astounding variety of trajectories. These considerations make it attractive for Gallistel (1981, p. 618) to assume that oscillations are the primitives in action schemata—the alphabet in which every schema is written.

(neuronlike) "computing" units in the connectionist system of SOCIETY, a unique network that classifies stimuli into distinct response categories, a network that develops—and pushes forward cultural evolution—by experiencing itself? Individuals do not transmit large amounts of symbolic information (they are "information-tight" in the sense of Ashby (1956)), but "compute" by being appropriately connected to large numbers of similar units, that is, in computer terminology: the program resides in the structure of these local interactions. During development, that is a learning process, environmental influences modify the inter-unit connection strengths to facilitate classification. The associational connectivity that is subject to modification by learning, the variable global gain under motivational factors, and, most importantly, the ability to change from a low level receiving state to high-level transmitting state, are key attributes of such a network. This class of models is called by Rumelhart *et al.* (1986, volume 1), *neural network models* with parallel distributed processing. Adopting this model, we posit that the connectionist repertoire of acquired and retained experiences constitutes the system's (society's) mind. The functioning of this repertoire or reference domain depends on the state of arousal of the system, on its motivational state and the genetic as well as neural "knowledge already there" (see Plato's *Meno*).

The mind is, after all, not in the head! Mind is a boundary condition between the infant and society, a society that suffuses the growing child with its (*i.e.*, society's) mind. Children who are not raised within and by society but by wolves, for example, do not develop a human mind (MacLean, 1977); they have no upright posture, run on four legs, have expressionless faces, eat raw meat, speak no language, prefer to live among wolves and dogs, and shy away from human beings.

Evidently, all higher mental functions are internalized social relationships... Their composition, genetic structure, and means of action—in a word, their whole nature—is social. Even when we turn to (internal, individual) mental processes, their nature remains quasi-social. In their own private sphere, human beings retain the function of social interaction, argues Vygotsky (1981, p. 164).

Mind is in the interaction between society and the individual, the creator of that same society which creates him. It is within this hermeneutic circularity that mind prevails as an interactional process: comparable to the bitterness of quinine or the sweetness of sugar (interaction processes that exist solely in the interaction between taster and taste). Where is the bitterness of quinine without anyone tasting it? Where is the mind of an isolated (imprisoned) individual?

The Western conception of an individual mind, as an autonomous unit, a unique and dynamic center of awareness, emotion, judgment and action is a romanticized fiction of "Faustian Man"—a typical Superman-type male fantasy—with its roots in the Renaissance. The individual mind may be but the replicating unit of cultural evolution in the sense that genes are replicating units of phenotypic organisms. The ultimate units of replication in cultural evolution are for Stuart-Fox (1986) mentemes or "meaning relations".

Coda

"Mind" is a tactical and syntactical artefact of the adjective "mental" and refers to particular cortical brain functions originating in social relationships that are internalized by the developing infant.

The real individuals within the ecosystem are species (Eldredge, 1986), and the mind of the human species is in its "brain": the interconnected network of society that develops by experiencing itself.

Mind may be matter's spontaneous organization that recognizes itself as "order out of chaos", but we perceive it as our own behavior. Anaxagoras, around 462 B.C.—in Fragment 12—(cited by Rössler, 1987), attributes the "unmixing" of the intermixed primordial state of extraordinary uniformity—that is, chaos, the "perfect mixture"—to a single entity that had been too "fine", or in our terms, more time-like than space-like, to be miscible: νοῦς or mind. Hence "in the beginning" was the making of distinctions, the creation of categories, that is, an "unmixing" of chaos. Ever since, the process of mind, mind as invention and mind as inventor—out of chaotic matter—continues to evolve... from *mythos* to *logos* or rationality, another recent discovery out of mind. In a parallel development, post-Newtonian or non-classical science replaces the (much too) general concept of God with another potentially creative agency: stochastic chaos. Mind seems to cerebrate and celebrate its origin from chaotic matter.

Both the separation of the observer into "thinking substance" and "extended matter", by Descartes, and their contemporary re-unification (and happy marriage in the brain, thereafter) were mediated by the logic and language of the observer. This self-same logic and language is the functional link—the feedback—between (brain-)matter and mind—a job done by God in Descartes' system—reflecting an almost complete return to tradition. The only notable change brought about by the intervening social discourse, or *Zeitgeist* (in the logic and language) appears to be a shift from theological phraseology (Supreme Intelligence) to a teleological one, *i.e.*, to a "non-local" intelligence (the non-linear dissipative operator of a processor), that is instrumental in compressing or abstracting stimuli, as solutions of the processor's dissipative dynamics. Thus the external world is made to collapse onto a set of stable *eigen-functions* or categories (strange attractors) or the perceptual-conceptual ordering of the (external and internal) universe into a hierarchy of abstract patterns (Nicolis, 1986).

Clearly, the distinction between mind and matter is a matter of mind, as already recognized by Anaxagoras in his doctrine of *Mind and Matter*:

> The things that are in a single world are not parted from one another, nor cut away with an axe, neither the warm from the cold, nor the cold from the warm. When Mind began to set things in motion, separation took place from each thing that was being moved, and all that Mind moved was separated (quoted by Jammer, 1974).
> For the Judeo-Christian West the separation took place when "God divided the light from the darkness" (Genesis 1,4) a primórdial creative division and categorical distinction: "order out of chaos", the first patterning of time.

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