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Consciousness Reassessed

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> *There used to be a guide to the famous maze at Hampton Court that showed the quickest route to take. Nobody who used it ever reached the center, which lies not in the unraveled, but in the unraveling.*
>
> John Fowles (1978)

1. Introductory

Many sophisticated essays and books have been written about the topic of consciousness. My own contributions date back some twenty-five years in an essay entitled "Problems concerning the structure of consciousness" (Pribram 1976), and five years before that in delineating the difference between brain processes that are coordinate with awareness and those that are coordinate with habitual behavior (Pribram 1971a). I have been intrigued by what has been written since and take this occasion to reassess a few of the major issues that have arisen.

The reassessment focuses on the "how" of mind-brain transactions. These are currently subsumed as first-person and third-person viewpoints. Definitions of consciousness such as those used in medicine (e.g. coma, stupor, sleep, and wakefulness) come obviously from a third-person vantage. Also the various studies on "theories of mind", which infer that we understand one another, take primarily a third-person stance. Other third-person approaches include descriptions of attention, intention and thought that are discussed in some detail in this essay. The current attempt is to approach the issue of conscious experience from a first-person perspective as fleshed out by the "how" of third person research.

1.1 The Primacy of Conscious Experience

For each of us all inquiry, and therefore knowing, begins with our own experience. This experience becomes "conscious" when it becomes accessible to being monitored. Monitoring can be proactive or retrospective. The experience develops as interpretive transactions occur between our genetic heritage and its biological, social, and cultural context. Acknowledging this primacy is relevant to many of the issues that are currently so hotly debated. For example, by approaching the mind-brain relation in a top-down fashion, brain processes are not seen as homunculi, little people inside little people inside the head. Instead, brain processes become understood as some, but not all, of the organizing influences that compose our conscious experience. Understanding develops as we explore these experiences. Understanding at any moment is hermeneutic and therefore partial, as is most scientific understanding.

My version of a top-down approach to understanding conscious experience is hostile to an eliminative reductionist, materialist stance (Churchland 1986, Crick 1994, Churchland 1995), no matter whether that stance is epistemic or ontic. In contrast, my view respects each scale of inquiry on its own level. There is, however, tolerance for a weak form of reduction: At the boundaries between scales *identities in the form of transformation rules*, translations between languages are sought. Understanding at each scale is experienced as a process in its own right, without losing sight of the interrelations and transformations that encompass the whole (Pribram 1971b, 1999; King and Pribram 1995, Pribram and Bradley 1998).

A cathedral may be made of bricks, but understanding the "cathedralness" of the structure is not limited to understanding bricks (nor even understanding the importance of buttresses that allow Gothic soaring). We may smash matter into particles but understanding the material universe is not limited to understanding particles. We note drops of water as they drip from a faucet and can make quantitative measures on drops. But where are the drops once they are gathered in a bucket? Do our measurements on drops *per se* account for the crystalline structures of snowflakes?

Having proclaimed this *caveat*, I want to add: but isn't it fascinating and exciting to know of all these bits and pieces, how they are put together, and to what purpose! That is the story of the exploration of our conscious experience.

For example: I experience the color red. I note that people stop at red traffic lights. Perhaps they have had similar experiences to mine. In another context and at a different time I learned that, in terms of physics, the color red corresponds to a specific bandwidth of a spectrum of electromagnetic radiation. But I also found out that this experience is specific to a particular context of illumination. For instance, I see the same colored objects as having a different color under ultraviolet illumination than under ordinary light.

Further along in my career, I studied color vision in preparation for my medical school thesis and was surprised to find that the central part of the retina, the fovea that we ordinarily use in daytime to see patterns, had very few (somewhere around 7%) receptors for the wavelengths of the spectrum that we identify as blue. Our color vision seemed to be composed either by receptors sensitive to only two types of "color" (Wilmer 1946) or one "color" and white (Land 1986). The primary sensitivities are combined at further processing levels into opponent types of sensitivities (e.g. blue and yellow and red and green). But opponent processing had to be rooted in "something blue", and the root was feeble.

Not until recently has a sophisticated brain model of color vision been composed. Russell and Karen DeValois based the model on all the earlier work and on their own and others more recent psychophysical and neurophysiological data (DeValois and DeValois 1993). They used a low frequency (red) and a medium frequency (yellow) as the "primary" types of receptors and brought in the higher frequencies (blue) as modulators. The model also accounts, within the same neuronal network, for the reception of black/white necessary for the perception of shape. For me, the successful outcome of decades of detailed experimentation and theoretical attempts at solving a mostly ignored physiological observation has been a heart-warming experience.

In an entirely different realm of inquiry, I heard that cultures differ in the number and sort of color which people in those cultures can share with others. This is a good example of how my experiences become meshed with those of others. In the 1960s, nomads in northern Somalia were unable to distinguish red from green, nor could they distinguish red from yellow or black in ordinary circumstances. In their semi-desert environment red was rarely if ever experienced. But they distinguished many shades of green and had names for these shades. Peace Corps volunteers were unable to differentiate between these many shades.[1]

Interestingly, some Somalis could distinguish colors such as red, orange and purple: They were tailors and merchants who dealt with colored fabrics. In short, they had been trained to perceive. The question arises as to whether these people experience the variety of colors prior to training. I have a personal story that sheds some light on this issue: When two colleagues and I began to study the anatomical composition of the thalamus of the brain, all we could make out was an undifferentiated set of stained cells. One of us complained that the thalamus looked like a bunch of polka dots. After months of peering down a microscope and comparing what we were looking at with atlases and published papers, the differentiation of various nuclear structures within the thalamus became obvious to us. We had reached "inter-subjectivity" which, in other contexts, has been referred to under the heading "theory of mind". Continued study and experimentation over several years enabled us to publish substantive contributions to the organization of thalamic organization and, additionally, to the role this organization plays in its connections to the brain cortex. On the basis of these findings I was able to distinguish a difference in organization between the posterior convexity of the brain and that of its frontolimbic formations, excursions into what Moghaddam (2003) calls inter-objectivity.

[1] Karen Shanor, personal communication.

In a ground-breaking set of experiments, James and Eleanor Gibson (1955) showed that perceptual learning consisted of progressive differentiation, not enrichment through association. My conclusion is that those cultures that do not communicate a rich diversity of colors have the capacity to do so but do not actually experience that richness until they learn to do so.

To summarize: Science and personal observation have discovered a great deal about conscious experience of color: some physics, some biology, some brain science, some social and cultural facts. I believe that by taking into account these observations and experimental results as well as showing their limitations and contextual constraints, we can say that we have some "understanding" of our conscious experience of the color red as one facet of the world within which we live and act. Contrary to the over-ambitious pronouncements of some (or is it many) current philosophers of science, scientists gratefully search for such partial understandings: *Conscious experience itself is the starting point, not the end of knowing and understanding.*

1.2 The Privacy of Conscious Experience?

Many philosophers of science currently contend that one of the most intractable problems in studying consciousness is that my consciousness (i.e. first-person consciousness) is for all practical purposes inaccessible to others (i.e. from a third-person point of view). This issue has been called one of the hard problems dogging scientific understanding of conscious experience. But if one's conscious experience is the starting point and not the end of inquiry, we come to realize that, in fact, we are very good at communicating our first-person conscious experience to others and to ourselves. The communication can be verbal or non-verbal.

Take the reflex of withdrawing one's hand from a hot flame or pot (René Descartes' example). It is possible, by repeating the behavior, to condition the response so that withdrawal would take place before the pot is touched (a fractional anticipatory reaction in stimulus-response psychological theory). But by becoming aware of the withdrawal and the hotness of the pot, not only can we abbreviate the process of not touching hot pots but, in addition, we can transmit what we know to our children and roommate (who might be an absent minded professor). Consciousness is what it says: "con-sciousness", to know together.

My claim is that the problem of communicating to ourselves and to others what constitutes my personal experience is not that different from experiencing observations in the physical sciences. Watching an oscilloscope screen that supposedly tells me what is going on within an atom or viewing through a telescope the images that appear to relate to the happenings in the stellar universe are fraught with uncertainties and subject to the contexts (e.g. the devised instruments) by which the observations are made. Ernst Mach (1897/1959), whose father was an astronomer, based his whole career on trying to distinguish the "subjective" aspects of physical observations. His legacy (Mach bands; see Ratliff 1965) attests to the importance of the *psych* in psychophysics: a grey spinning wheel that is continuously varying in shade from center to periphery looks to us as if the shading were discontinuous and banded. Even more dramatic, David Bohm (1973) pointed out that should we observe the universe without lenses it would appear as a hologram. As a neuroscientist, I noted that the same consideration must apply to the role of the lenses of the eye and the lens-like structures of other sensory receptors (Pribram 2004a). Without these receptor organs we would experience the world we live in as a hologram.

We observe and communicate with others, we develop tools for more acute observation, and we formulate the results to receive consensual validation that we are on the right track. What is really private are the unconscious processes to which we have such limited access. Sigmund Freud's contribution (see, e.g., Pribram and Gill 1976, Pribram 2004b,c) was to attempt a technique by which we could access these unconscious processes and bring them into our conscious experience so that we could share them and do something about them.

Thus, through consciousness we become related to each other and to the biological and physical universe. Just as gravity relates material bodies, so consciousness relates sentient bodies. One can no more hope to find consciousness by digging into the brain than one can find gravity by digging into the earth. One can, however, find out how the brain helps organize our relatedness through consciousness, just as one can dig into the earth to find out how its composition influences the relatedness among physical objects by gravitational attraction.

2. Matter and Mind

2.1 Observables, Observations, and Measurement

What is the specific role of the brain in helping to organize our conscious relatedness? A historical approach helps to sort out the issues. The matter-mind relationship can be considered in terms of distinctions. In the 17th century the initial distinction, sometimes called the Cartesian cut, was made by Descartes (1662/1972) who argued for a basic difference in kind between the material substance composing the body and its brain and conscious processes such as thinking. With the advent of quantum physics in the 20th century, the Cartesian cut became questioned. Werner Heisenberg (1930) discovered a limit to simultaneously measuring the momentum of a massive body and its location. Later, Dennis Gabor (1946) formulated a similar limit in communication, i.e. *minding*, because of a limitation in simultaneously measuring the spectral composition of the communication and its duration.

These indeterminacies introduce limits to our measurement of both matter and mind and, thus, the location of the cut between them. Wigner (1967) argued that the cut should be placed between our conscious observations and the elusive "matter" we are trying to observe. Niels Bohr (1961) argued more practically that the cut should be placed between the instruments of observations and the data resulting from their use.[2]

In keeping with Bohr's view, these differences in interpretation come about as a consequence of differences in focus provided by instrumentation (telescopes, microscopes, atom smashers, and chemical analyzers). Measurements made with these instruments render a synopsis of aspects of our experience as we observe the world we live in.

Figure 1 below provides one summary of what these measurements indicate both at small and large scales. The diagram is based on a presentation made by Chew at a conference sponsored by a Buddhist enclave in the San Francisco Bay area. I had known about the Fourier transformation in terms of its role in holography. But I had never appreciated the Fourier-based fundamental conceptualizations portrayed below. I asked Chew where I might find more about this and he noted that he had got it from his colleague Henry Stapp who in turn had obtained it from Dirac.[3]

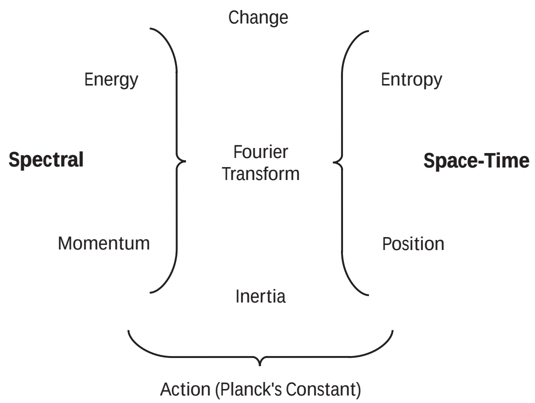

Figure 1: The Fourier transform as the mediator between spectral and spacetime descriptions. For a detailed explanation see text.

[2]For sophisticated reviews of how these scientists viewed the results of their observations and measurements see Heelan (1965) or Stapp (1997).

[3]Eloise Carlton, a mathematician working with me, and I had had monthly meetings with Chew and Stapp for almost a decade and I am indebted to them and to David Bohm and Basil Hiley for guiding me through the labyrinth of quantum thinking.

One way of interpreting the diagram in Fig. 1 is that it indicates *matter to be an "ex-formation", an externalized (extruded, palpable, compacted) form of flux. By contrast, thinking and its communication (minding) are the consequence of an internalized (neg-entropic) forming of flux, its "in-formation".* Flux, or holoflux (Hiley 1996), is here defined (Pribram and Bradley 1998) as representing change, measured as energy (the amount of actual or potential work involved in altering structural patterns) and inertia (measured as momentum). Bohm (1973) proposed a similar concept which he called holomovement. He felt that my use of the term "flux" had connotations that he did not want to buy into. I, on the other hand, felt holomovement (ordinarily a spacetime concept) to be vague and misleading since there is nothing being moved. We are dealing with spectra, distributions of energy and momentum measured in terms of frequency (or spectral density). In the nervous system such distributions have been recorded as representing activity of dendritic receptive fields of neurons in sensory cortices (Pribram 1991, King et al. 2000, Pribram et al. 2004).

The diagram in Fig. 1 has two axes, one top-down and the other right-left. The top-down axis distinguishes change from inertia. Change is defined in terms of energy and entropy. Energy is measured as the amount of actual or potential work necessary to change a structured system and entropy is a measure of how efficiently that change is brought about. On the other hand, inertia is defined as momentum, and location is indicated by its spatial coordinates.

The right-left axis distinguishes between measurements made in the spectral domain and those made in spacetime. Spectra are composed of interference patterns where fluctuations intersect to reinforce or cancel. Holograms are examples of the spectral domain. I have called this pre-spacetime domain a potential reality because we navigate the actually experienced reality in spacetime.

The top-down axis relates mind to matter by way of sampling theory (Barrett 1993). Choices need to be made as to what aspect of matter we are to "attend". Brain systems coordinate with sampling have been delineated and brain systems that impose contextual constraints have been identified (Pribram 1959, 1971a).

My claim is that the basis function from which both matter and mind are "formed" is flux (measured as spectral density). This provides the ontological roots from which conscious experiences regarding matter (physical processes) as well as mind (psychological processes) become actualized in spacetime. To illuminate this claim, let me begin with a story I experienced: Wigner once remarked that in quantum physics we no longer have observables, but only observations. Tongue in cheek I asked whether that meant that quantum physics is really psychology, expecting a gruff reply to my sassiness. Instead, Wigner beamed a happy smile of understanding and replied, "yes, yes, that's exactly correct". If, indeed, one wants to take the reductive path, one ends up with psychology, not particles. In fact, it is a psychological process, mathematics, that describes the relationships organizing matter. *In a non-trivial sense current physics is rooted in both matter and mind* (cf. Chapline 1999).

Conversely, communication ordinarily occurs by way of a material medium. Bertrand Russell (1948) addressed the issue that the form of the medium is largely irrelevant to the form of the communication. In terms of today's functionalism it is the communicated pattern that is of concern, not whether it is conveyed by a cell phone, a computer or a brain. The medium is not the message. *But not to be ignored is the fact that communication depends on being embodied, instantiated in some sort of material medium.*

This convergence of matter on mind, and of mind on matter, gives credence to their common ontological root. (Pribram 1986, 1999). My claim is that this root, though constrained by measures in spacetime, needs a more fundamental order, a pre-spacetime potential that underlies and transcends spacetime. The spectral bases of the quantal nature of matter and of communication portray this claim.

2.2 Identity and Multiple Instantiations; Neither Reduction nor Multiple Aspects

Many of the problems that fuel the current discourse on consciousness are due to the acceptance of a radical reductionist stance. Take Francis Crick's view (Crick 1994) that if we knew what every neuron is doing we would dispense with folk psychology. But what every neuron is doing is a complex process composed of synapto-dendritic fine fibered transactions, circuits, modules composed of circuits and systems composed of modules. The complexity of our experience can also be hierarchically organized into levels of organization, scales of processing, that must be taken into account if we are to relate the organization of our experience to the organization of the brain (see, for instance, King and Pribram 1995).

With regard to the complexity of neural organization, it is important to return to Russel's (1948) *caveat*: there is a great deal that can be learnt about brain processes that is irrelevant to the transduction and modification of informational patterns that form our conscious awareness. Of course, it is important to know how brain matter is constituted in order to prevent and to heal breakdown. But much of this knowledge does not contribute to the critical relationships that describe how brain processes contribute to the organization of mind. This is essentially the argument of the functionalists.

Memory storage is a case in point. Material scientists are needed to develop the best substrates for making CDs and DVDs. In earlier times the development of tape recordings went through several phases of finding a suitable recording material. Initially, recordings were stored on wire – I remember well the irritating tangle such wires got themselves into: a hardware Alzheimer's disease. Embedding the wires into plastic solved that problem. What is it in normal brains that prevents such tangles from occurring? Whatever it is, it is most likely not directly relevant to the code that is instantiated in the neural tissue, wire, tape or CD.

To repeat: *The medium is not the message.* The message becomes embedded in one or another limited but essential characteristic of the medium. It is up to brain scientists interested in behavior and in conscious experience to discern what this characteristic is – to sort the wheat from the chaff.

With regard to the hierarchical complexity of experience, insights can be gained by taking computers and computer programs as metaphors. An *identity* in structure characterizes both the binary machine language (in terms of bits) and the basic hardware operations of the computer. Octal and hexadecimal coding represents a condensed encoding scheme (into bytes) by triplets and quadruplets. What is seldom recognized is that the size of a byte determines a minimal form of parallel processing (as this term is understood in the construction of massively parallel distributed processing (PDP) computational architectures). *The change in the syntactic scheme from bits to bytes allows a change from a code where meaning resides in the arrangement of simple elements to a pattern where meaning resides in the structure of redundancy, i.e. in the complexity of the pattern. In this scheme each non-redundant element conveys a unique meaning.*[4] A further set of hierarchically ordered programming languages leads to the capability for the input and output devices to address the computer in a natural language such as English. At the lower level of the hierarchy it is often useful to implement the software in hardware and *vice versa.* But for higher-order programs this is infeasible.

At the level of natural language programming, a dualist philosopher might point out that the material computer and the mental program partake of totally different but somehow interacting worlds. In fact, for several years the hardware machinery could be patented, while copyrights protected the narrative-like high-level programs.

With respect to brain processes and psychological processes, a fundamental *identity* is established by a Gabor-like elementary function (see Pribram 1991 for review). Dennis Gabor (1946) developed a windowed Fourier transformation to discern the maximum compressibility of a telephone message without losing intelligibility. Beyond this maximum, an indeterminacy holds, that is, the meaning of the message becomes uncertain. Gabor's measure of uncertainty is related to Shannon's measure of

[4]For details as to how such coding schemes are implemented in computer hardware and in the nervous system see Pribram (1971b, pp. 66–74).

the reduction of uncertainty, the bit, as the basic unit of current computer information processing. Gabor (1946) introduced a quantum of information on the basis of the same mathematics as Dirac used to describe the microstructure of matter (see Figure 2).

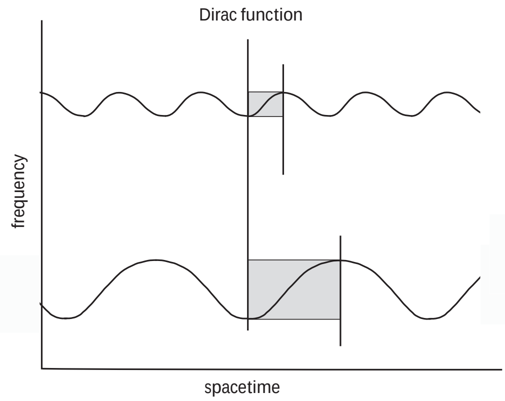

Figure 2: Schematic illustration of Gabor's elementary functions as quanta of information. See text for further details.

During the 1970s and thereafter, experiments in many laboratories including mine showed that the Gabor function provides a good description of the architecture of activity in cortical dendritic fields to sensory stimulation (DeValois and DeValois 1988, Pribram 1991). Thus, the same mathematical formulation describes an elementary psychological process, communication, and an elementary material process in the brain.

The Gabor quantum of information can, therefore, serve the same function for the wetware/minding relationship that the bit serves for the hardware/software relation. English is not spoken by the computer, nor are there photographs in the computer when it processes the takes of a digital camera. Likewise, there are no words or pictures in the brain, only circuits, chemical transactions and quantum-like holographic (holonomic) processes based on Gabor-like wavelets. To use another metaphor, the processing of an fMRI (functional magnetic resonance imaging) tomograph uses quantum holography. The pictures we see are reconstructions made possible by the process.

Not only radical materialists but also identity theorists claim that neurological and psychological processes partake of sameness. I have stated something like this in the preceding paragraphs but limited the identity to the most elementary structural descriptions of brain and psychological processes. In higher, more complex organizations, meaning no longer resides in the arrangement of simple elements (the amount of information) but rather in the structure of redundancy. Complex organizations progressively depart from identity until they appear as duals far removed in structure and content from one another. Nonetheless at their roots, a structural identity such as the Gabor elementary function, a dendritic quantum of information, can be discerned.

This perspective leaves another issue unexamined: Not only bit processing but natural language word processing by computers is also instantiated in processing hardware. Does this indicate an identity between natural language and the hardware? In the case of the computer there is a hard drive consisting of a CD-like disc that can be addressed by running the program. Storage is location-addressable and can be increased by supplemental CDs. In image processing by tomography (such as fMRI) the medium permits a content-addressable distributed process (quantum holography akin to Gabor's windowed Fourier transform) to be instantiated. There must be some sort of "identity" between the patterns inscribed in the grooves of the storage medium and the natural language, but the transduction into those grooves and back out must be implemented (literally) by input and output devices that include the kind of programming steps already noted.

Memory storage occurs in the brain and partakes of both distributed processing in the fine fibered arbors (dendrites) and content-addressable processing in the brain's local circuitry. I have termed these aspects of memory storage and retrieval "deep" and "surface" structures (Pribram 1997b, Pribram and Bradley 1998). As in the case of the hardware metaphors there are input and output steps in processing that suggest caution in assigning an identity to the relation between the experienced and the brain patterns.

I will take a case in point: Cells in the temporal lobe of the brain of monkeys have been found to respond best (though not exclusively) to front views of hands. An identity (or materialist) theory might be overjoyed with such a result. Of course, as has been pointed out, for a neuroscientist, the question of the "how" of hand recognition has simply been pushed back into a neuron from consideration of the whole person. I found such cells in monkeys who had been trained to choose a green stimulus in an earlier experiment. In these monkeys the best response was to green hands and green bars. In other laboratories, Fourier decomposition of the stimulus showed that, in fact, the cells were responding to the Fourier descriptors of the stimulus (the tangent vectors to the outlines of the stimulus). The point is that the brain process does not look at all like what I am experiencing, and probably not what the monkey is experiencing.

I must belabor this issue because eliminative materialists might claim that all they are arguing for is that some form of explanation of experience in brain terms is called for and that, when this explanation is complete, we no longer need to use folk psychology to describe our conscious experience. Next time you are at Times Square in New York, just note to your scientifically unwashed colleague: look at that beautiful Fourier transformed tangent descriptor outlining the opponent process of the limited spectrum to which we can respond. He thinks you are balmy and says it's just the illuminated picture of a pretty girl. And he's conveyed a good deal more than you have.

A final *caveat*: I have distinguished information from matter (exformation). Died-in-the-wool (might I say wooly-headed) materialists do not buy into this distinction. For them, information is some sort of matter or its equivalent energy (see Pribram 2004a on the spatialization of energy). Functionalists tend to ignore the problem of the instantiation of informational patterns, a problem brain scientists cannot ignore. Hopefully, I have suggested a direction that allows unpacking these issues.

The main unanswered question for identity theory has been how the identity comes about. One answer has been that brain processes and psychological processes are different aspects of some more basic process. Linguistic philosophers termed this a difference between brain talk and mind talk. The problem then arises as to what is that untalked-about basic process? For an extensive and sophisticated philosophical discussion of the multiple aspects (though not the multiple instantiations) view that in many respects is close to mine see Velmans (2000). My answer (Pribram 1986) has been that the untalked-about ontological basic process is identified as flux (describing measurements of energy and momentum in terms of frequency.[5]

My additional claim is that by identifying flux as their ontological basis function, brain organization and psychological organization become more than merely multiple aspects, multiple perspectives, of some unspecified underlying order. Transformations of flux into spacetime coordinates specify material and temporal locations of information and meaning. Thus, multiple aspects describe actual instantiations, embodiments, of an underlying order (Pribram 1971a,b, 1997a). This statement is a more precise rendering of what is intuitively called "information processing" by the brain (Velmans 2000).[6]

3. Brain and Experience

3.1 Co-Ordinate Structures Relating Brain to Conscious Experience

Science is most often an analytical process. The structural perspective presented here is both analytic and synthetic. For practical purposes a considerable amount of analysis has to precede structural synthesis.

[5]Note that the mathematical use of frequency is neutral to time and space: in audition, frequency determines the pitch, time the duration of a tone.

[6]See also Gabora (2002) for an interesting and detailed perspective on how brain processes "amplify" phenomenal information.

Within an analytical perspective, there are two disconnects that have to be dealt with: one is between the organization of conscious experience and the organization of behavior. The other is between the organization of conscious experience and the organization of brain processes.

With respect to the disconnect between the organization of conscious experience and behavior, take the example of driving an automobile avoiding other cars, stopping at red traffic (but not other) red lights while engrossed in a conversation with a passenger.

With respect to the disconnect between the organization of conscious experience and the organization of brain processes, there are innumerable examples. For instance, particular stages of brain processes that organize vision operate in the spectral domain while our experience is in spacetime. This is similar to the operation of fMRI where the apparatus operates in the quantum holographic domain while the resulting pictures emerge in spacetime.

Another example is that my experience of self is unitary. However, under certain conditions two rather different selves can be discerned: an objective "me", and a monitoring narrative "I" (Pribram and Bradley 1998). When part of my body (or brain) is tampered with, for example my face after a dentist's novocain injection, or an injury to the right parietal cortex of the brain, an objective "me" experiences a change in the contents, the objects, of the experience. My experience is about the imaged distortion of the (essentially unchanged) face and about the loss of the body image of an arm (which is perfectly intact and may in fact perform, i.e. behave, normally).

A rather different set of experiences constitute an "I", a narrative self composed of experienced episodes of events that are monitored by attention, intention, and thinking (Pribram 1999). Experienced episodes no longer become a part of the narrative "I" after lesions of the frontolimbic formations of the brain.

As noted, the differences between experiencing the self as a "me" and as an "I" have been shown to be coordinate with, but not identical to, differences between the organization of brain processes. By coordinate I mean that there are transfer functions (codes, languages) that, at the boundaries between the experienced and the neural scales of organization, allow descriptions at one scale of organization to become related to the description of others. The transfer functions that allow coordinate descriptions between the organization of experiential, behavioral and brain processes have made up the chapters and lectures of my books and essays (e.g. Pribram 1971b, 1991, 1999).

Taking conscious experience as the result of the complex of relations among brain systems, body systems, social systems and culture, the "cement" that unites them is stored memory. Relevant brain processes operate by virtue of neural modifiability that results in the brain's memory store. Physical, biological and social consequences of behavior are memorable, both in changing brain organization and in changing culture. The cultural consequences that have developed, such as new technologies and new linguistic usages, feed back on the brain to alter its memory store, and the consequent brain processes feed forward onto culture. Karl Popper incorporated this theme into "three interacting worlds": culture, brain and mind (Popper and Eccles 1977, see also Pribram 1971b, Chapters 2, 14, 15, and 20).

Linguists have noted that a reductionist approach, in which causal relations are sought, works for simple systems, but for complex systems a structural analysis is needed. Consciousness is complex. The exclusive search for efficient causes is misplaced. Formal causes, embodied in the structure of the transactions and, on occasion, even final causes are more appropriate: Brain processes intend cultural artifacts as in originally designing a piano (a cultural material memory) and in subsequently creating a piano sonata (a cultural mental memory). As I attend a happening and remember it, my brain's memory systems are altered and can be altered thoughtfully in such a way that my intended future behavior will be affected propitiously as, for instance, in operant conditioning or more complex self-organizing transactions.

3.2 A Spatiotemporal Hold

Given this necessary dependence between mind and matter, and between matter and mind, how do the transactions between them actually take place? How are memories formed?

With regard to their neural locus, the basic transactions between matter and mind occur in the fine fibered branches of neurons (teledendrons and dendrites) and their connections (synapses and ephapses) in the brain (the evidence is reviewed in Pribram 1971b and 1991). However, such transactions need to be transmitted between sites by the larger nerve fibers (axons) for interactions among brain sites to occur. These interactions take time. The problem is that axons of various diameters and lengths must synchronize the transmission of the basic transactions. Llinás (2002) has developed a tensor model (see also Pellionisz and Llinás 1979, 1985) that takes these differences in transmission into account. Llinás suggests that transmission time in the nervous system cannot be our experienced time, but rather something more like an Einsteinian Minkowski spacetime.

Both Llinás' model and mine develop invariants by utilizing a convergence of sensory inputs and motor outputs to form entities, i.e. objects. Mathematically this is described as linear covariation among sensory inputs (by both Llinás and Pribram) and nonlinear contravariation among motor outputs (by Llinás mathematically and by Pribram neurologically). Input and output converge on a "world point" that provides for our perceptions of objects. Llinás' theory and mine are complementary regarding their neuroanatomical referent and their mathematical description. I have elsewhere detailed this complementarity (Pribram 2004a).

On the behavioral side, a stepwise process can be discerned to occur. Operant conditioning provides a useful example of this process. Fred Skinner (1989), a radical behaviorist, stated that "there are two unavoidable gaps in the behavioral account; one between a stimulating event and the organism's response; the other between the consequences of an act and its effect on future behavior. Only brain science can fill these gaps. In doing so it completes the account; it does not give a different account of the same thing."

In the 1960s and 1970s I proposed that a temporal hold characterizes the brain processes that fill these gaps. The first gap, that between a stimulating event and the organism's response, is negligible when the response is reflexive, habitual and/or automatic. However, when awareness is experienced the temporal hold becomes decisive. Sir Charles Sherrington (1906/1941) phrased the issue as follows: "Between reflex [automatic] action and mind there seems to be actual opposition. Reflex action and mind seem almost mutually exclusive – the more reflex the reflex, the less does mind accompany it." I noted that habitual performance results from the activity of neural circuits in which the currency of transaction is the nerve impulse as in Llinás' tensor theory. Mind, awareness, on the other hand, demands a delay between processing patterns arriving at synapses and those departing from axon hillocks. The delay occurs in the fine fibered connectivity within circuits (cf. Pribram 1971b, pp. 104–106).

Regarding the second gap, recently performed experiments have shown that during learning such a delay is imposed by the frontal cortex on the systems of the posterior convexity (Pribram 1999). For example, a visual input activates the occipital cortex, then the frontal cortex, and then again the occipital cortex. As a consequence, in a learning task such as during operant conditioning, the frontal cortex has been shown to be critically involved. In these experiments an experimenter interposes a delay between stimulus presentation and the opportunity for response. Monkeys readily master such tasks. But when the frontal cortex is temporarily anesthetized learning fails to occur. This has been shown to be the result of a failure of a frontal "hold" to occur, a hold that ordinarily activates cells in the more posterior parts of the brain during the delay part of the task.

In spacetime terms, the temporal hold is closely related to a spatial hold. Time is measured as the duration of a movement through space (like on an analogue clock face). The spatiotemporal hold can help to explain Libet's findings which have puzzled neuroscientists for decades (cf. Libet 1982). Libet showed that selective electrical stimulation of the somatosensory cortex is not "sensed" for a quarter to a half second after the onset of the stimulation, whereas peripheral stimulation is sensed immediately. He showed this to be due to a backward-in-time projection to the occasion of the peripheral stimulation. Bekesy (1967) demonstrated that in the auditory domain the spatial projection (as in stereophonic systems) also operates as a temporal projection: eliminating the spatial projection, he tried to cross a street and found that he could not anticipate an oncoming car. Suddenly the sound "hit" him with such intensity that he doubled over.

Another feature of the spatiotemporal hold that is essential to conscious experience is that peripheral stimulations immediately engage a much larger cortical field than do cortical stimulations. Electrical excitation of the sciatic nerve, for instance, evokes reposes over the entire central part of the cerebral convexity (including the so-called motor and premotor cortex) even in anesthetized monkeys (Malis et al. 1953). In addition, my colleagues and I identified a mediobasal (limbic) motor cortex that governs viscero-autonomic processing involved in conditioning, learning and remembering (Kaada et al. 1949, Pribram et al. 1979, reviewed by Pribram 2003).

But these mediobasal and classical precentral "motor" cortices do more than control particular movements or viscero-autonomic effects *per se*. They are, in fact, sensory cortices controlling action, that is, the projected achievement of a target (cf. Pribram 1971b, 1991). As such they encode what Skinner called "behavior", the environmental consequences of an action, enlisting whatever movements necessary to carry out the act. (Skinner stated that, for him, the behavior of an organism is the paper record of accumulated responses that he took home to study.) If the precentral process contributes to awareness at all, it is the errors in the environmental consequences of the behavior, not the trajectory of the sensory receptors (the scans) or the movements, by which to accomplish a percept or an action. The parallel in vision is that we do not sense the trajectory of saccades, only the visual image effected by them. Visual image and the environmental consequences of an action come to awareness some time later than the saccade and the movement itself.

Stimulation of the classical central (Rolandic) sensory and motor cortex *should* not be coordinate with awareness. If we were aware of our actions at the time they are occurring, we would mess them up (Miller et al. 1960). Imagine being aware of your tongue and palate as you are giving a talk – in fact, occasionally, when your mouth becomes dry, you do become aware and just can't go on. Or playing tennis or batting at baseball – the adage is "keep your eye on the ball". When taking notes during a lecture, conscious attention is on what the lecturer is saying, not the writing of notes. Furthermore, the receptors and muscle contractions, the movements involved, can vary according to whether one is watching a video, listening to the professor, using a writing pad, a laptop computer or standing at the blackboard. To repeat: the primary sensory and motor systems provide the encoded intended consequences of an action, not just the particular movements needed to carry them out. Thus, these systems need to function autonomously during the course of an action; only when, after a spatiotemporal hold, they act in concert with other brain systems do they participate in organizing any necessary change in future acts by way of conscious intervention.

There is another piece of evidence that supports the involvement of a spatiotemporal hold in achieving both conscious experience and learning. When we first began to study event-related brain electrical potential (ERP) changes, we learned a great deal by using what is called an odd-ball technique. A particular stimulus is presented repeatedly, and occasionally a different (but somewhat related) stimulus is randomly interposed in the series. The recorded ERPs are then averaged separately for the two types of stimulus presentation. The averaged records for the two types of stimuli are dissimilar especially around 300 milliseconds after the presentation of the stimulus. We interpreted the change in the ERP for the odd-ball stimulus as indicating that an update in the perception of the stimulus sequence was occurring. But subsequent experimentation showed that another dissimilarity in ERPs could be observed at around 400 milliseconds and that updating did not occur (i.e. the dissimilarity at 300 milliseconds continued unchanged) unless the 400 milliseconds dissimilarity was present. In short, the dissimilarity at 300 milliseconds indicates that an update (often consciously experienced) is necessary, and the one occurring at 400 milliseconds heralds the actual updating (i.e. learning is occurring). According to all this and much other evidence (reviewed by Pribram and McGuinness 1992) achieving conscious awareness involves specific brain systems and takes processing time.

3.3 The Road to Supervenience

Ignoring the spatiotemporal hold has led some philosophers to opt for one of two very different accounts of the relationship between our conscious experience and brain processes. One such account states that, in fact, there is no relationship, that conscious experience is a useless epiphenomenon – which in the extreme would hold that consciousness was invented by God to torture us. The problem with epiphenomenalism is that there is much evidence against it: Often the pen *is* mightier than the sword. We imagine musical instruments and musical phrases and stir others when we implement them.

Another attempted explanation, somewhat less extreme, is that the relationship simply exists by virtue of supervenience, that is, an immediate, unexplained, downward causation. For supervenience, the major problem is to account for "how" it is accomplished (cf. Velmans 2000). What might be the relation between ineffable mind and palpable matter? According to the view proposed earlier in this essay, the answer lies in the complementary relationship between matter and mind as a two-way dependence of ex-formation (matter) on in-formation (communication) and in-formation on ex-formation – in less technical language: on information processing by virtue of brain processes. Pursuing this formulation of the issue goes a long way toward resolving this issue.

But another issue needs a different resolution. Much of what we consciously experience is indeed an emergent informational epiphenomenon (unless we can get to use it in a talk show). Non-conscious, automatic processing takes up the major portion of the brain's metabolism. The question so put is which brain systems and processes are responsible for that aspect of conscious experience that supervenes on brain processes so as to modify them for future use, and how does it do so?

My answer is that much of conscious experience is only initially epiphenomenal; and further, that supervenience occurs by virtue of the spatiotemporal hold. It is the hold that allows behavior, defined as the consequence of the organism's action, to mediate the registration of an experience so that it becomes available to the brain's future processing. Conscious experiences are initially emergent from brain processes produced by input generated by the brain's control over its physiological, chemical, physical and sociocultural *environment.* When changes occur in that environment, changes are produced in the brain processes. Only when these peripheral changes become implemented in the brain's memory do the resulting experiences become accessible to further processing.

Implementation is stepwise: The patterns that describe conscious experience are induced by a neural pattern, i.e. by a temporary dominant focus, an attractor. The neural pattern develops over 300 milliseconds when novelty is encountered (novelty can be generated internally when there is a shift in perception of an ambiguous figure such as a Necker cube). Over another 100 milliseconds the attractor, the temporary dominant focus, gains extended control over brain processing, for instance through spectral phase locking between frontal and posterior cortices (cf. Gabora 2002).

Consciousness of an experience, when attained, thus can affect subsequent automatic brain/behavioral processes by virtue of gaining control over them, allowing changes to occur consonant with the experienced novel context. In a sense the experience itself is momentarily an epiphenomenon: though produced by inputs to the brain, these brain patterns and the conscious experiences are ordinarily fleeting and do not immediately become coordinate with any lasting brain patterns. The effect of the conscious experience has to become proactive.

Thus, supervenience is not effected by some immediate conscious mental pattern being impressed on (or matched to) a pattern of brain processes. Supervenience depends on a temporal hold that makes possible several shifts in brain processing away from controls on sensory and viscero-autonomic inputs, shifts in the location of temporary dominant foci (attractors). These shifts allow the brain patterns coordinate with the initial experience to co-opt other brain processes that ultimately control consequent behavior. Behavior, in turn, modifies viscero-autonomic and sensory processes that, in their turn, modify subsequent shifts in attractors until the novel experiences become implemented. (See Section 4.2 for more details.)

4. Modes of Conscious Experience

4.1 Types of Brain Organizations

In earlier presentations (Pribram 1976, 1977) I identified three modes within which the attractors operating in the brain help organize our experience. These modes are states, contents and processes. Conscious states are organized primarily by neurochemical states. The wealth of psychopharmacological influences on moods such as depression and elation, attests to this relationship. The biochemical and biophysical substrates of anesthesia, sleep and dreaming are being investigated at the synaptic, dendritic, membrane, channel and microtubular scale (see, for example, John 2000, Hameroff 1987, Hameroff and Penrose 1995, Jibu et al. 1996).

The *contents* of consciousness, ordinarily spoken of as perception, are addressed by DeValois and DeValois (1988) and by myself (Pribram 1991). There is a wealth of evidence on how different brain processes influence the organization of the contents of consciousness. In a recent paper (Pribram 1999) I addressed additional issues which, from *traditional* philosophical perspectives, are discussed in terms of "intentionality". In these traditions, intentionality is defined differently from intention in the sense of purpose (see Sec. 4.4). Also, "intensionality" (see Sec. 4.2) differs from intentionality. Intensionality concerns the intensive aspects of experience that are contrasted to its extensional aspects.

To return to "intentionality": Brentano (1874/1929) noted that just as all of our intentions need not be actualized, so also our perceptions are directed toward an object, but the object need not be realized. Brentano spoke of "intentional inexistence" using the parallel between unfulfilled intended acts and unfulfilled perceptions as in imagining a unicorn. Husserl simplified Brentano's term to "intentionality", again emphasizing that the process need not refer to an actual sensory input.

Human clinical evidence and experimental evidence obtained with nonhuman primates has shown that the systems centered on the posterior convexity of the brain are involved in the intentional aspect of conscious experience. Separate such brain systems can be distinguished: those controlling egocentric (body-centered), allocentric (beyond the body, outercentered) and object centered "spaces". By contrast, the basal frontolimbic forebrain is critically involved in the intensive aspects of experience in terms of experiencing episodes of novelty and of disruption of ongoing processes. These same parts of the brain control a readiness to bind these episodes together into a narrative (Pribram 1999, Pribram and Bradley 1998, Koechlin et al. 2003).

However, these very same brain organizations are molded by biological and social factors that are, in turn, organized by the brain organizations. Human brains are critical to the invention of bicycles, the writing of novels and the construction of economic systems that, in turn, mold brain organization. The phenomenological approaches to conscious experience by Brentano and his followers Husserl (1931) and Heidegger (1966) acknowledge these interrelationships, but do not detail the necessary experimentally based data (especially what the brain and behavioral sciences currently have to offer) that pull it all together.

Nor does their "Lebenswelt" (Husserl) or "In-der-Welt Sein" (Heidegger) detail the structural precision of the processes that are involved in the reach from being to becoming in the material aspects of the world. This is the essence of Prigogine's contributions (e.g. Prigogine 1980, Prigogine and Stengers 1984). Prigogine provides such structure in descriptions of self-organizing systems forming far from equilibrium. Further details of such processes have been worked out (see, for instance, Pribram 1994, Pribram and King 1996) in terms of phase spaces that contain attractors that "pull" rather than causally "push" organizational complexity. What needs to be done is to place these data based advances in the theory of matter into the framework of phenomenological analysis in order to forge a comprehensive theoretical frame for a science of psychology (see Heelan 1983, Pribram 1981).

The *processing* mode of conscious experience binds state with perceived content and content with state. I am in a state of hunger and thirst and suddenly perceive hitherto ignored restaurant signs all over the place even when they are written in the Russian alphabet (Zeigarnik 1972). I am on my way to work, urgently considering the days tasks when I pass a doughnut shop. Perceiving the fresh baking odors stops me in my tracks, I perceive the store window with its display and I go in and buy a couple of the doughnuts because now I am in a new state, I feel hungry.

Conscious processing can, in turn, be parsed into (1) attention as pre-processing sensory, kinesthetic and visceral inputs; (2) thinking as pre-processing remembering; and (3) intentions as pre-processing motor output. These pre-processings will form the grist to the mill of the remainder of this essay.

4.2 Attention

At one point William James exclaimed that he was tired of trying to understand consciousness and that we should rather stick to understanding attention. Of course, he did not do so but noted that attention is a good starting place to examine the issue of how in-formation supervenes on the ex-formation of the brain.

Skinner's realization that the brain is critically involved in the operant conditioning process provides a key in this context. Experience does not immediately supervene on neural processing during a perception or an action. Rather, at any moment, neural patterns are generated by a novel and unexpected sensory input or composed by an internal set of ongoing events. These neural patterns act as temporary dominant foci, as attractors (cf. Pribram 1971b, pp. 78–80). The neural circuits involved operate efficiently to preprocess further sensory input or preprocess an action. Ordinarily these preprocessings proceed with no time for "mind to accompany them" as Sir Charles Sherrington (1906/1941) so eloquently put it. Once preprocessing is completed, control shifts automatically to other patterns in response to current demands – unless there is an intervention by some novel happening (see Miller et al. 1960). Much has been made of an action-perception cycle. By contrast, what I am emphasizing here is an automatic-conscious processing cycle.

The automatic (unconscious) processes are, at any moment, more like feedforward programs than error sensitive processes subject to correction by feedback. We are not aware of the process by which we prehend an object. As noted, this is a good thing – we'd only mess up. So, does that leave us with all conscious experience as an epiphenomenon? Not at all. After I reflexly remove my hand from a hot flame, I contemplate the happening. Our cat is an excellent example: he looks at his paw and licks it, then looks at the offending object and reaches out toward it but this time does not touch it. He repeats this procedure several times over. If I may anthropomorphize, the cat's conscious awareness of the incident, his ERP at 300 milliseconds and the later change at 400 milliseconds indicate how awareness of what has happened alters (preprocesses) future behavior. In the example given, the cat's attentional prepreocessing reinforced the change in subsequent behavior several times – in operant conditioning terms the cat's observational behavior was shaping the changes in his behavior. And the non-behaviorist claim is that the shaping can occur, not only non-consciously, but also by way of conscious awareness of what is happening. *Conscious attention shapes subsequent behavior.*

4.3 Thinking

What about the patterns that characterize our thought processes? Do they supervene directly onto patterns of brain activity? Freud (as well as many others) defined thought as implicit action and based his talk therapy on that principle. According to the view that I have here assembled, implicit action remains implicit, i.e. we remain unaware of the ongoing processing. Freud pointed out that these preprocesses constitute the person's memory when looked at retrospectively. At the same time they are that person's motivation when looked at prospectively (Pribram and Gill 1976). When we become aware of the results of this preprocessing, i.e. when we consciously think about something, we actually do involve the body's effectors, muscles and glands. Watson was not far off in his physiological behaviorism. Evidence continues to accumulate that very slight changes in muscle tone or in breathing or heart rate variability occur during thinking (see, for example, a review by McGuigan 1976). William James and, more recently, Antonio Damasio have called attention to the involvement of feelings as bodily responses to what happens and how these feelings influence cognition and the making of choices (Damasio 1994). What is being made explicit is that these physiological body responses change brain preprocessing (re-membering) so that subsequent thinking becomes modified.

My claim therefore is akin to that made by William James, but adds whole body attitudinal inputs and the environmental consequences of behavior. For the preprocessing of memory that motivates a thought to become conscious, it must be "taken to heart" and acted upon through viscero-autonomic, gestural or subvocal acting out. Action on the body and on the world must take place, albeit sometimes only subliminally and tentatively, to shape the memory-motive structures, the temporary dominant foci, the attractors characterizing the patterns of brain preprocesses in thinking.

Karl Popper is close to this formulation in his concept of the necessary interaction among "three worlds" to achieve consciousness. Popper's three worlds are brain, culture and mentation (Popper and Eccles 1977). Contemporary suggestions indicate that a "fourth world", the body, must be added to these interactions. Thus and only thus can the pen be mightier than the sword.

4.4 Intention as Free Will

Taking the primacy of conscious experience as the starting point of inquiry resolves not only such issues as "downward causation" as discussed in the previous sections, but also addresses the issue of free will. A scientific reading of what constitutes freedom would state that, although one's actions are constrained in a variety of ways, the measure of the degrees of freedom that remain is experienced as free will. Voluntary, intended behavior rests on a parallel feed-forward pre-process in which a signal presets the execution of the process (Helmholtz 1909/1924, Teuber 1964, Sperry 1980). Helmholtz used the example of saccadic movements of the eyes that place the retina where it needs to be to receive the "desired" input, i.e. the target of the intent.

Much has been made of the fact that brain processes can be recorded prior to the execution of a voluntary act. But, as noted, thank goodness my behavior is not burdened with continuous conscious experience appropriate to the behavior. Even my spontaneous lectures in a classroom run off at a rate that would be impeded by any awareness of how I am saying something. Awareness comes from watching the faces of the students – I must slow down, ask for questions etc.

In other words, contrary to Einstein's view, God does play dice with the universe and with you and me. The six-sided die even has numbers on it – it is highly constrained, determined. But throw the dice (two of them) and you have a great many possibilities as to how they will land. The initial conditions are determined by the six-sided dice – the throw, the dynamics, are constrained only by gravity and the gaming table, and, for all practical purposes, remain remarkably undetermined. And conscious experience, because it comes late allows humans to influence future contextual constraints (the gaming table) on the basis of their experience – how else would casinos stay in business?

In short, my claim is that freedom comes from action, from doing something with the constrained anatomy, the structure of the situation. As described by non-linear dynamics, the future depends on initial conditions and the constraints operating at any moment. These determine the degrees of freedom, the state space within which the trajectories of the process must operate. Equally important is the noise in the system so that the action is not constrained only by the first attractor that is encountered (the first well in the landscape) – that is why the roulette wheel is actively rotating. When my colleagues and I (Pribram et al. 1979) studied classical conditioning in amygdalectomized monkeys, the animals failed to become conditioned. The failure was shown to depend on the reduction (when compared with the behavior of normal control subjects) of variability (noise) in their initial responses to the unconditioned stimulus and were, therefore, unable to bridge the time gap necessary for them to connect the conditional stimulus to the unconditioned stimulus. Simply put, they were more constrained, more compulsive, than their controls.

5. Coda

5.1 Pervasive Consciousness

Defining an aspect of conscious experience in terms of narrative indicates that experience partakes of a larger consciousness, tunes into that more encompassing knowing together. Taking the stance that I have taken in this essay, it is only a step from the existential conscious experience of living in this physical, biological, social and cultural world to defining the cultural world as spiritual. By spiritual I mean that our conscious experience is attracted to patterns (informational structures) beyond our immediate daily concerns. Such patterns may constitute quantum physics, organic chemistry, history, social interactions, economics or religious beliefs. These interests all comprise stories and the same part of the brain that is involved in creating the narrative "I" is involved in partaking in these other narrative constructions (see Pribram and Bradley 1998).

The search for understanding is indeed a spiritual quest whether esoteric, artistic or scientific. Understanding consciousness as developed in this essay ought to go a long way toward unifying these quests.

5.2 Summary

The primacy of conscious experience, from which all (including scientific) knowing is derived, resolves many of the issues now so fervently debated by both philosophers and scientists. First, the privacy of conscious experience is contested: in fact, it is conscious experience, as opposed to unconscious processing, that is the medium of communication.

Second, communication, minding, replaces ineffable mind in portraying the matter-mind relationship. Mapping this relationship by means of the Fourier transformation, matter can be seen as an "ex-formation" constructed from a basic holographic-like flux from which minding is also constructed as "in-formation." Matter and minding are mutually dependent on one another: it takes mathematical minding to describe matter, and minding, communication, cannot occur without a material medium.

Third, given this portrayal of the matter-mind relationship, certain aspects of information processing by the brain can be tackled. To begin with, the timing within circuits of the brain cannot be within experienced time (duration) because the paths of conduction are varied with regard to both length and fiber size that determine the speed of conduction. If communication of a pattern and/or synchrony is to be achieved, a higher-order spacetime (such as developed in the theory of relativity) must be operative.

This is one indication that brain processes coordinate with conscious experience must be forged much as a musical instrument must be forged to provide a medium for the production of music. Forging takes place within spacetime and involves not only brain processes *per se* but inputs from and outputs to the body as well as the physical and sociocultural environment.

On the basis of identifying brain systems coordinate with consciousness, at least two modes of experience can be identified: (a) an "objective me" distinguishable from an objective other, and (b) a "monitoring, narrative I" constructed of episodes and events. Paradoxically, the same brain processes that are coordinate with the "monitoring, narrative I" are also coordinate with experienced spirituality.

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