Bergson, Perception and Gibson

Stephen E. Robbins
Center for Advanced Product Engineering
M&I Data Services
11000 W. Lake Park Dr.
Milwaukee, WI 53224

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Abstract

Bergson's 1896 theory of perception/memory assumed a framework anticipating the quantum revolution in physics, the still unrealized implications of this framework contributing to the large neglect of Bergson today. The basics of his model are explored, including the physical concepts he advanced before the crisis in classical physics, his concept of perception as "virtual action" with its relativistic implications, and his unique explication of the subject/object relationship. All form the basis for his solution to the "hard problem." The relation between Bergson and Gibson as natural compliments is also explored, with Bergson providing the framework that explicates Gibson's concept of direct perception, with Gibson's resonance model as a precursor to dynamic systems models of the brain and his reliance on invariance laws defining perceived events providing more detail for the mechanisms Bergson only envisioned from afar, and with Bergson providing the basis for an otherwise missing Gibsonian model of direct memory.

Bergson, Perception and Gibson

1. Introduction

In 1896, a book entitled Matter and Memory was published by a young French philosopher, Henri Bergson. The book was considered remarkable by many at the time. His vision of the material universe has been seen in retrospect by physicists as having anticipated concepts of quantum wave mechanics (de Broglie, 1947/1969). His vision of memory was radical, for he proposed that the brain was not, save for the forms of memory we might now call procedural or implicit, the storehouse of experience at all. His theory of perception was considered profound, in fact too profound, for it was admitted even by admirers to be obscure. At his peak, after the publication of Creative Evolution in 1907, he was one of the most famous and popular philosophers of the times. And today, his neglect in the literature of consciousness, memory and perception is, with very occasional exceptions (e.g., Shanon, 1993; Gunter & Papanicolaou, 1987), nearly complete.

In retrospect, we can understand those who felt things to be obscure. The reason I think is twofold. Firstly, Bergson was developing a theory of consciousness within a framework of physical thought which anticipated a crisis in classical physics yet unforeseen and other discoveries yet to come. Secondly, it was a theory of direct perception precursing even Gibson's elusive concepts, and as well, a theory of direct memory. But this theory was embedded in a theory time and its relationship to mind which has yet to be grasped.

The neglect of Bergson has, I think, hidden a theory of consciousness with much to offer for today's thought. Bergson had clearly anticipated arguments such as Searle's (1992), rejecting the concept that computational descriptions can somehow explain, let alone generate consciousness, computations being neither "natural kinds" nor anything capable of supporting supervenience relations. To Bergson, mathematics could only be "a descriptor of the real", i.e., of the real dynamics of the brain. Thus neither Dennett (1991) who rejects the binding problem and puts his faith in computational description relating to something of which we cannot speak, nor Jackendorff (1987) who accepts the binding problem but would have computations somehow generate experience, would have held much allure. Chalmers' (1996) attempt to show the equivalence of a dynamic neural net to a "demon" running from synapse to synapse, writing connection strengths on slips of paper, the notations on the slips now in effect "maintaining the causal relations," would have been seen as misguided. The real dynamics, not the abstraction, is critical. But within the real dynamics is the binding problem. "How can the multi-modal, coherent world of experience, even in principle, be brought about by the combinatory mechanisms of neurons and neuron assemblies?" asks Revonsuo (1994). Are synchronizing oscillations or mechanisms across the whole somehow Baars' (1988) "global workspace" in action? But even a global workspace must somehow become experience, the experience of the external "world-out-there." Bergson, particularly when taken in union with Gibson, provides an exciting new framework in which to answer this question.

In this paper, I would like firstly to explicate the model of perception/consciousness Bergson proposed. I would like to show that his theory is the natural frame in which to place Gibson, that it is Bergson that can make sense of Gibson's concept of direct perception and provide as well the beginnings of the missing Gibsonian model of memory. With the growing awareness of Gibson and his "resonance" model as a precursor of the dynamic systems models of the brain (Port & Van Gelder, 1995), it will be apparent why this class of model strongly requires Bergson's framework of time and mind to gain coherence. Gibson and his dynamic resonance will in turn provide more substance for the mechanisms Bergson required but could only vaguely describe. Together, a new framework for approaching what is currently termed the 'hard' problem will emerge.

2.0 The Physical Context

The theory of mind we are about to explore is framed within Bergson's model of the physical world, and this model is that of modern physics, reaching into some of physics' more extreme implications. Physics has attempted to explore ever more fully its counter-intuitive vision of the material world. The psychological sciences, however, particularly those embracing the computer model of mind, tend to hold the opinion that "quantum effects" are irrelevant, simply "canceling out" at the relevant scale of study, i.e., at the brain and its neural processes (Cf. Pinker, 1997; also Simon, 1995). But a point has been missed. Focusing on "quantum effects" obscures physics' larger and more profound vision of space and time, a vision of reality which could indeed have a huge effect on the way we think about consciousness and the brain, for in it the "brain" is (or is not) as much an "object" or a "particle" of our theories as the "particles" of physics. Thus psychology has spent the last 100 years essentially in the classical framework of space and time. The theory of mind we now explore attempted, even before physics, to throw this away, exploring a more profound reality.

Bergson's foundational insight was to the nature of time. Time, he held was a reality absolutely distinct from space. It could not be treated as a series of "instants," where each instant would in turn correlate with a spatial <u>position</u> occupied by an object moving along some spatial trajectory. This analysis equivalences time to a dimension like those of space, where time becomes simply a series of points on a space-like line. Real time, he held, is better modeled after a melody, where each "note" or "state" permeates or melts into the next, forming a continuity - a "succession without distinction," a mutual interpenetration (Bergson 1889).

Bergson's twofold insistence on the invalidity of treating motion as a series of positions and on the unreality of the discrete "instant" of abstract time has its accompaniment in an emphasis on the unreality of abstract space. Abstract space, Bergson stated, is a purely mental structure. Extended around us lies the material world. Across this extension we place, as it were, a mental mesh or net, the meshes of which we may draw in to squares as small as we like. Ultimately each square/mesh becomes a point, and we end with the concept of the extended world as a continuum of points or spatial positions. But to concrete, extended matter, argued Bergson, this is a complete unreality.

De Broglie, writing in 1947, enumerated certain correspondences between Bergson's vision of the physical world and quantum physics as then developed. One such, he noted, is quantum mechanics' demonstration of the impossibility of attributing to an elementary particle simultaneously a well-defined state of motion and an entirely determinate position - Heisenberg's uncertainty relationship - $\Delta x \Delta p \sim h$. Stated simply, as we decrease our uncertainty of an elementary particle's position, we necessarily increase our uncertainty of its momentum, and vice versa. The measurement tends, in a way, to project the particle to a point in our abstract space or geometric continuum, but could we do so, we would have lost all motion! We end, in other words, in precisely the state that Bergson described when one attempts to treat a motion as a series of points, immobilities or "states," i.e., we have lost the motion.

At the classical level, we are surrounded by "objects" and "motions." This is a perceptual partition of the concrete, extended world, that, as we shall discuss later, is effected by the body/brain for the purpose of action - so we can pick up a "fork" or a "piece of popcorn" or throw a "rock." At this level we might still think of the trajectory (as a series of positions) of a moving object. But at the micro-level, we are forced to deal with a reality that leaves our mental concepts of the material world, derived from the need for practical action in our scale of time, behind. As Bergson argued, "...a theory of matter is an attempt to find the reality hidden beneath...customary images which are entirely relative to our needs..." (1896, p.254). In quantum mechanics, no trajectory is assignable to a moving object, for one can determine through a series of measurements only a series of instantaneous positions, while simultaneously renouncing all grasp of the object's state of motion. Thus Bergson noted, "In space, there are only parts of space and at whatever point one considers the moving object, one will obtain only a position" (Bergson 1889, p. 111). This was written more than forty years before Heisenberg.

De Broglie wrote his comparison somewhat before the initial writings of Bohm (1980; 1987) on the quantum potential with its non-local entanglements of parts changing as features of a whole, features which led to Bell's theorem and its prediction of non-local (faster than light) effects (Bell, 1987). Bohm's vision too, I believe, is implicit in Bergson. By treating motion as a set of changes of position in an abstract space, we are led to the logical conclusion of this framework, i.e., relativity, though relativity in the sense of Einstein is not intended here (neither the special nor the general theory) but rather in the classical sense of Mach, often called Galilean relativity. Thus, rarifying this spatial treatment, the mathematician expresses movement as the change in distance of a point from a set of spatial axes. But the same change of distance can be effected either by a movement of the point, or a movement of the axes away from the point. The same object then can be either at rest or at motion according to the frame of reference. But there must be real motion:

> Though we are free to attribute rest or motion to any material point taken by itself, it is nonetheless true that the aspect of the material universe changes, that

> the internal configuration of every real system varies, and that here we have no longer the choice between mobility and rest. Movement, whatever its inner nature, becomes an indisputable reality. We may not be able to say what parts of the whole are in motion, motion there is in the whole nonetheless. (1896, p. 255)

And continuing:

> Of what object, externally perceived, can it be said that it moves, of what other that it remains motionless? To put such a question is to admit the discontinuity established by common sense between objects independent of each other, having each its individuality, comparable to kinds of persons, is a valid distinction. For on the contrary hypothesis, the question would no longer be how are produced in given parts of matter changes of position, but how is effected in the whole a change of aspect... (1896, p. 259)

We have made an artificial division in the continuity of the concrete extended world around us. Driven inexorably by the very needs of our body to identify aspects of the whole that can serve for nurture and sustain life, Bergson insisted, perception must create separate "objects" and concomitantly their "motions." But he says: "No doubt the aspect of this continuity changes from moment to moment, but why do we not purely and simply realize that the whole has changed, as with the turning of a kaleidoscope?" (1896, p. 260).

This dynamically changing whole has properties far from those dictated by a thought structure derived from the fundamental needs of the body to act. What is a "particle," he asked, but the extension in thought of this bodily perceptual process by which useful "objects" were first identified in the whole. It is a concept derived purely for practical action which will never, imported into the realm of pure knowledge, explain the properties of matter.

> But the materiality of the atom dissolves more and more under the eyes of the physicist. We have no reason for instance, for representing the atom to ourselves as a solid, rather than as a liquid or gaseous, nor for picturing the reciprocal action of atoms by shocks rather than in any other way. Why do you think of a solid atom, and why of shocks? Because solids, being the bodies on which we clearly have the most hold, are those which interest us most in our relations with the external world... (1896, p. 263)

Between these "particles" we now envision forces of attraction at work, ultimately even a gravitational effect between all objects in the universe.

> Something, then, exists between the atoms. It will be said that this something is no longer matter, but force. And we shall be asked to picture to ourselves, stretched between the atoms, threads which will be made more and more tenuous, until they are invisible and even, we are told, immaterial. But what purpose can this crude image serve? (1896, p. 264)

But what happens to this image?

> And, indeed, we see force and matter drawing nearer together the more deeply the physicist has penetrated into their effects. We see force more and more materialized, the atom more and more idealized, the two terms converging towards a common limit and the universe thus recovering its continuity. (1896, p. 265)

And so physics moved inexorably. The Rutherford atom would astound the imagination with its vast spaces of “nothingness” between nucleus and electrons. From Bohr's quantumization of these electron orbits, we moved to a period of the discovery of myriads of sub-particles - muons, gluons, leptons, etc. - all eventually subsumed under the theory of quarks. But the quarks, with their various "spin" states, became even less material, and we are asked to abstract from the spin state of a quark all mass, leaving an abstract mathematical point with its value of "spin." Below this now are postulated the "strings," inconceivably small violin strings as it were, whose harmonics give rise to the whole of the field of matter. And thus, in the end, contemplating the dynamic movement of this field: “ ...they show us, pervading concrete extensity, modifications, perturbations, changes of tension or of energy, and nothing else” (1896, p. 266).

And this dynamically changing universe, this kaleidoscope, Bergson saw as in essence a holographic field. In this field, “brain” and “body” and surrounding “objects” have no more independent or mutually external reality than the “particles” of physics.

3. Bergson's Theory of Perception

Bergson began by stating that we must accept the obvious, like it or not, about the function of the brain. The brain, he argued, should be regarded as "an instrument of analysis with regard to movement received, and of selection with regard to movements executed" and "(The higher centers of the cortex) do but indicate a number of possible actions at once, or organize one of them" (1896, p. 20). Thus the essential function of the brain (as with Sperry, 1952) was viewed as the preparation of an array of appropriate motor acts relative to the surrounding environment. Significantly missing is the function so usually sought, i.e., the representation and generation of the image of the external world.

In Bergson's conception then, the energy transmitted through (or resonating within) the cerebral system (Bergson's "movements") was transformed into incipient or "nascent" action. Highly related to, but beyond Gibson's notion of the perception of "affordances," the perceived world thus became the reflection of an array of action possibilities.

> (Objects) send back, then, to my body, as would a mirror, their eventual influence; they take rank in an order corresponding to the growing or decreasing powers of my body. The objects which surround my body reflect its possible action upon them. (1896, pp. 6-7)

The <u>order</u> being carved out of the ambient energy flux is a particular order defined relative to the action capabilities of the organism. Bergson stated this notion succinctly in the concept that perception is <u>virtual action</u>.

3.1 Perception as Virtual Action

We have been seeing phenomena implying aspects of the concept of virtual action for some time. Gibson, as noted, would incorporate aspects of it in his notion of "affordances" – properties of the *perceived* environment in reciprocal reference to the action capabilities of the organism. The motor theory of perception essentially assumed that the process of perceptual selection (of information in the visual or auditory field) is constrained or guided by motor schemes, i.e., by implicit knowledge that the central nervous system has with regard to movements it is capable of producing (Liberman & Mattingly, 1985). And subsequently a large number of findings have pointed to the general concept that the objects and events of the perceived world are in a real sense mirrors of the biologic action capabilities of the body (Cf. for example Viviani & Stucchi, 1992; Viviani & Mounoud, 1990; Glenberg, 1997), while the appreciation of the importance to visual computation of re-entrant connections from motor areas to visual areas has also grown (Churchland *et al.,*1994). However the virtual action concept is deeper, deeper perhaps to the point of explaining why, as Weiskrantz (1997) has discussed re the findings of Nakamura and Mishkin (1980; 1982), blindness can result simply from severing visual area connections to the motor areas.

Bergson, as did Mach, visualized the universe as a field of immense motion or "real actions." Any given "object" acts upon all other objects in the field, and is in turn acted upon. It is in fact obliged:

> ...to transmit the whole of what it receives, to oppose every action with an equal and contrary reaction, to be, in short, merely the road by which pass, in every direction the modifications, or what can be termed <u>real actions</u> propagated throughout the immensity of the entire universe. (1896, p. 28)

An "organism" however presents an "object" of a different sort. In many respects it acts upon and is acted upon like other objects - it <u>is</u> an ensemble of particles after all. However, to a certain subset of these actions or influences which it receives from the field, there is a difference, for these are relatable to its action capabilities. This subset becomes "virtual action." After the analogy of optics, rather than passing through, these actions are "reflected," giving rise to a virtual image of their point of origin.

3.2 Bergson's Holographic Conception

How is it that this reflection becomes the image we have of things? Bergson argued that in stating the problem as one of accounting for how perception (the image) arises, we are on the wrong track immediately. It leads us to cling to the notion that perception must be a photographic view of things - a photograph (or yes, representation) taken and developed in the brain. Thus we ask how this subset of real actions gets "developed" as the picture we have of things. But he says:

> But is it not obvious that the photograph, if photograph there be, is already taken, already developed in the very heart of things and at all points in space. No metaphysics, no physics can escape this conclusion. Build up the universe with atoms: Each of them is subject to the action, variable in quantity and quality according to the distance, exerted on it by all material atoms. Bring in Faraday's centers of force: The lines of force emitted in every direction from every center bring to bear upon each the influence of the whole material world. Call up the Leibnizian monads: Each is the mirror of the universe. All philosophers agree on this point. Only if when we consider any other given place in the universe we can regard the action of all matter as passing through it without resistance and without loss, and the photograph of the whole as translucent: Here there is wanting behind the plate the black screen on which the image could be shown. Our "zones of indetermination" (organisms) play in some sort the part of that screen. They add nothing to what is there; they effect merely this: That the real action passes through, the virtual action remains. (1896, pp. 31-32)

Bergson's theory was clearly a holographic theory, some fifty years before Gabor's 1947 creation of the hologram. The lack of Gabor's physical model only added to the difficulty of comprehension by Bergson's contemporaries. To Bergson, the universe was a vast holographic manifold - a "photograph...at all points in space." In a hologram, it scarce needs repeating, the information for any given point of an object is spread throughout, while conversely, at any given point of the hologram is found the information for the entire object.

At a given instant of space-time, Bergson was arguing, the state of any point-instant is the reflection of the whole. But Bergson was well aware of the dynamic aspect of this statement. He had argued, we noted, that the concept of a discrete "instant" of time is an illusion, that the model of time is that of a melody, where each "note" permeates or interpenetrates the next, forming an organic continuity. Thus the state of any point-instant is in fact the reflection of the entire history of the holographic field. From this perspective the universal field has an elementary aspect of memory.

The problem then is not how perception arises, but how it is limited. The holographic field, or in its dynamic aspect as Bohm (1980; 1987) termed it - the holomovement - is perception in its most basic form – and this will be unfolded more fully in subsequent sections. The problem is to explain individual perception as a limited subset of this field, i.e., how it is possible to pass a reconstructive wave through the hologram (or holofield) such that a specific subset of the information contained at any point is displayed as the virtual image of the external world. Bergson saw this being effected via the operation of the perceptual/action systems of an organism.

I do not intend here to motivate further the physical concept of the universe as a holographic field. Bohm (1980; 1987) attempted this extensively; aspects of recent theory such as Maldacena's incorporate it (Oz, 1999). Accepted as a postulate, I think we shall see that the theoretical benefits are profound. However the virtual action principle as part of this conceptual framework contains a relativistic implication which must be seen to understand this model. This implication begins with the understanding of the natural *scaling* created by dynamic systems, and to this we first turn.

3.3 The Body/Brain, Scales and Dynamics

Bergson (1896, pp. 266-277) called attention to (and built upon) the significance of the fact that the body must determine a particular *scale* of time, that an infinity of various scales or "tensions on time" in his terms, is possible. Why do we see the multiple oscillations of a fly's wings as a blur, rather than as the flapping wings of heron? Why, as Bergson noted, do we experience 400 trillion oscillations of an electromagnetic field as the quality red? How would the world appear if our perception were closer to each developing oscillation? We live at a particular scale, but it is not the only possible.

Consider for example an experiment where we have a cube constructed of wire edges and rotating at a constant speed (Turvey, 1977b). Every such object has a symmetry period. If we consider rotational symmetry, the period is given by the number of times the object is mapped into itself or carried into itself in a complete rotation of 360 degrees. Thus a square, if rotated about its center, is completely carried into itself every 90 degrees, and has therefore a symmetry period of four (4 x 90 = 360). An equilateral triangle has a symmetry period of three, being carried into itself every 120 degree turn (3 x 120 = 360). A circle is considered to have a period of infinity, being completely carried into itself with even the smallest rotation.

If the room is dark and we strobe the cube periodically, the form that is actually perceived is totally dependent on whether or not the periodic strobes preserve this symmetry information! If we strobe in phase with or at an integral multiple of this period, an observer would see, as we might expect, a cube in rotation. But if the strobe is out of phase, e.g., 9 times or 13 times per complete rotation, what is perceived is not a cube in rotation, but a distorted, wobbly object. It is the information defined over *time* that specifies this form.

If we were to take a normal cube and place a rod through its center such that we could spin it, we would notice the following: At a slow rate of spin or rotation we would observe a *cube*, i.e., our familiar four-sided figure, in rotation. As the rate of rotation is sped up, something begins to happen - we begin to see a cylinder surrounded by saw-toothed or serrated edges. The number of edges must be an integral multiple (4 x n) of the cube's symmetry period, depending on the rate of rotation, i.e., 4, 8, 12, 16, etc. The faster the spin, the more edges appear, but always at this integral multiple, a figure of 4n-fold symmetry. At a high enough rate of spin, only a cylinder is observed, i.e., a figure of infinite symmetry. Now all these transformations of the cube are with respect to or aspects of our normal scale. Let us assume that the brain is indeed a dynamic system, and underlying this dynamically changing perception of the cube is an attractor. Let us consider such systems with respect to scales.

A typical example of a dynamic system is a cup of hot coffee with its convection flow. This flow is a slowly rotating cylinder of fluid within the cup, rising, then falling. If the coffee is initially so cool that there is no convection flow at all and we add a tiny bit of heat to the bottom center, a column of fluid will begin to rise in the center, turn over to the left and right, and descend on each side of the cup. There will be then two rolls of fluid, this initial divide into two rolls being termed of course a *bifurcation*. Given constant heat, the system with its two rolls will settle into a moving equilibrium. It is precisely the flow modeled by the Lorenz attractor. Now with more heat, an instability sets in. A “kink” or “wobble” develops in each roll and moves steadily back and forth. Now, at some point, with a bit more heat, the second bifurcation will occur. The system organizes itself into *four* cylindrical rolls. As the heat continues, the system will again bifurcate, this time into eight rolls. And so this bifurcation process and period doubling would continue.

Dynamical systems are naturally systems that *integrate* scales. The combined action of a myriad of smaller scale elements forms a large scale pattern. Thus actions of a myriad of coffee molecules are coordinated to form a large scale “roll.” Traditionally, however this understanding was not obvious. In the Newtonian framework, there was the vision of elements in motion, colliding with one another, acting and reacting according to laws of motion. At one scale, this may have been atoms. At another, it may have been molecules and at another, billiard balls. But when it came to describing how the motion of the molecules *created* the billiard ball, theory was silent. The billiard ball was just a collection of molecules. There was no discussion of the relation between differently scaled dynamics (cf. Keijzer, 1998). Only recently, in systems like our coffee

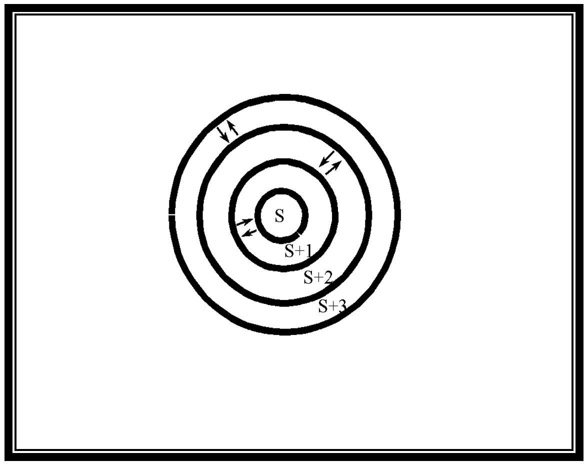

Figure 1 The nested dynamics of scales. The dynamics of scale S, e.g. the atomic, are most rapid. The dynamics of S+1 is built upon S, e.g., the molecular. The arrows represent interactions between scales. (After Keijzer, 1998)

cup - pumped with energy and far from thermal equilibrium - have we come to the idea of large-scale orders arising. The brain/body clearly contains a hierarchy of scales. There is the sub-atomic, atomic, molecular, the neural, the muscular and more. At each scale, things are occurring at a certain *rate*. At the atomic scale, events are happening extremely rapidly while by comparison events at the neural level are happening far more slowly relative to the atomic scale of time. This vast time difference has tended to reinforce the concept that different scalar levels are independent and do not interact. The dynamics of a molecule within a billiard ball are so fast that the billiard ball doesn't appear to change at all within the molecular time frame. But there are clear exceptions, especially in living systems. If we introduce a catalyst into the molecular level of an organism, the catalyst is able to speed up the rate of chemical reactions enormously. We now have created the conditions to see how the various scales in fact dynamically interact. In fact we have added another parameter driving the system to consider.

Suppose, while watching a swiftly spinning cube, we speed up the chemical velocities supporting the firing of the neurons in the brain, i.e., we speed up events at the molecular scale. The myriads of neurons themselves are supporting the large scale pattern of an attractor specifying the form perceived. What will happen now to this pattern? The coffee, due to its properties as a fluid, could only respond and form its roll patterns and bifurcations at a certain rate. And the neural "flow," like the coffee, can form its patterns only at a certain rate. The increasing rate of rotation of the cube drives the system at its normal rate of neural flow to form an attractor successively specifying an ever greater number of serrations up to some limit of resolution realized as a spinning cylinder. Suppose that at present this perceived form is a rotating cube with 16 serrations. .Now we change the properties of the neural "fluid." It now moves or flows more quickly. If the velocity of neural flow is driven increasingly higher, would we not expect the perception, i.e., the number of serrations, to change, moving from 16 to 12, to 8, etc.? But as the blurred wing beats of the fly define our normal scale, so do the perceived serrations of the cube at a certain rate of rotation at normal neural rates, and we have moved clearly to the origins of perceptual scale.

3.4 The Inherent Relativity of Virtual Action

Implied in the foregoing is the importance of what can be termed the body's "energy state." This is a state relating to the "energy of activation" required to initiate chemical reactions at a given velocity in the body (Cf. for example Hoaglund, 1966). The effect of a catalyst for example is simply to promote a reaction that would not begin at all at normal body temperature, or which would occur and continue only if supplied by a large amount of energy available only at a high temperature. An enzyme, as a catalyst, by orienting appropriate bonds, enables a reaction to proceed at body temperature, reducing the energy of activation normally required to initiate the process. We can conceive then of the physio-chemical status of the body as being described by a certain energy level or normal amount of energy (the energy state) required to initiate a given process at a given scale. The underlying chemical velocities of the body necessarily underlie processes supporting the initiation, computation and execution of action.

If the objects/motions of the perceived world are reflections of the action capabilities of the body as Bergson proposed, then what perceptual transformation occurs when the action capabilities change as a function of a change to the underlying energy state? With an increase in the energy state, perceived velocities (and therefore time) must slow, reflecting precisely the new capability for action. A buzzing fly might now be perceived, dependent on the magnitude of change in the process velocity supporting the action systems, as slowly flapping his wings. The cube will be perceived as rotating more slowly. But this must simultaneously be a reflection of the action capabilities of the body.

A physicist requires some sort of standard to define a unit of time and ultimately therefore a measure of velocity. Perhaps a single revolution of some nearby rotating disk is used to define a "second." So too does the body. Consider a cat that must intercept a mouse moving across his visual field. Assume that the mouse is moving with a uniform velocity from point A to point D with points B and C between (Figure 2). If the cat began his leap when the mouse is at A or B or C, the minimum velocity required to intercept the mouse at D would be increasingly greater at each point, with proximity to D approaching an asymptote. Let us call this "minimum required velocity" at each point V_{min}. It is clear that this state of affairs defines an increasing function relating V_{min} to the various points of the mouse's path. A series of mice moving at various velocities would generate a family of such curves or functions. But note that we have chosen a scale of units on the ordinate axis on which we have placed V_{min}. Since we are dealing with a velocity of action, we are dealing with a scale of units defined in terms of distance units divided by time, i.e., v=d/t. This time, and therefore this scale, are dependent on the body's own internal reference system, i.e., its energy state. When we raise this level, the standard of time and therefore velocity must change. Had we measured the velocity of the mouse traveling from A to D in terms of units of some process carried out by the body, we might now find that two such units can be carried out during the interval which the mouse takes from some point to the next as opposed to one unit formerly, in effect changing the scale of the function.

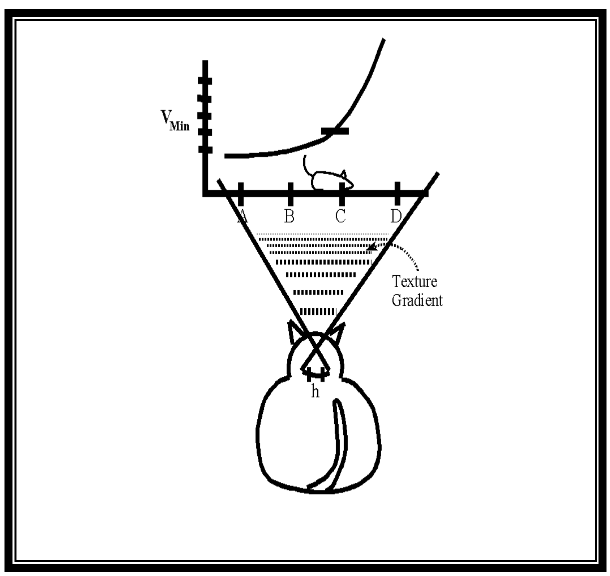

Figure 2 Hypothetical function describing the minimal velocity of leap (V_{min}) required for the cat to intercept the mouse at point D. Note that if we slide mouse and his track toward the cat, the distance h, projected on the retina remains unchanged, i.e., any number of such mice/tracks will project similarly on the retina.

The necessity of describing perception as virtual action now becomes more clear if I state it from this basis: perceived velocity is defined by the characteristic function describing the action system. This is simply to say, with reference to our example, that the perceived velocity of the object (mouse) must be lowered, for its perceived velocity must be a reflection of the new possibility of action at the higher energy state. There is a new (lower) V_{min} defined along every point of the object's trajectory, and therefore the object, *if perception is to display our possibility of action with ecological validity*, must appear to be moving more slowly. In the case of the rapidly rotating cylinder (once cube), if by raising the energy state sufficiently we cause a perception of a *cube* in slow rotation, it is now a new specification of the possibility of *action*, e.g., of how the hand might be modulated to grasp edges and corners rather than a smooth cylinder. If the fly is now flapping its wings slowly, the perception is a specification of the action now available, e.g., in reaching and grasping the fly.

It is worth noting here, in our context of the totally integral relation of perception and action, clearly implied in Gibson, that in Turvey's (1977a) mass-spring model of muscular action, there are "tuning" parameters defined within the dynamic state of the brain which ready the coordinative structures of the segmental apparatus for the cat's leap. For a "muscle-spring" these parameters are stiffness and damping, and necessarily, time. Stiffness would specify the end-point for an arm-thrust towards the fly or leap to the mouse. Note that we can translate the mouse and his track towards or away from the cat, and yet the horizontal projection (h) on the retina is the same, any number of such mice/tracks projecting similarly. Therefore h/t is not enough information to specify unambiguously the mouse's velocity and the needed information required for a leap. Thus the needed muscle-spring parameters must be realized *directly* in the coordinative structures via properties of the optic array, e.g., the texture density gradient across which the mouse moves and the quantity of texture units he occludes.

To realize just how complex is the (projected) dynamic invariance structure to which the brain is resonating over time, imagine that the mouse were moving across the texture gradient *towards* the cat. Now the size constancy of the mouse as it moves is being specified, over time, by the invariant proportion, $S \propto 1/N$, where S is the (increasing) vertical size of the mouse on the retina, N the (decreasing) number of texture units it occludes ($SN=k$). Then imagine not a mouse, but our rotating cube with its symmetry period, moving towards the cat!

Though I will develop this more below in the context of Gibson's emphasis on invariance laws, we can begin to appropriate here the relativistic concept of the *space-time partition* insofar as we are dealing with the relativization of perceived velocities and therefore of perceived time. The energy state, with its determination of action capability, determines simultaneously the specification of the 4-D extent of past states of the universal field and the time-scope of future action, i.e., the scale of time. A buzzing fly is a specification over a great many more states of the past than a near motionless fly barely flapping his wings. It is a much larger scale. This scale is in principle capable of varying from observer to observer, perhaps species to species. Now in Bergson's model, the organism (O) with its dynamically changing state of the body/brain, and the surrounding field or environment (E), still form a single system or field (E-O) - any spatial separation between the two is artificial. It is intuitively modeled as a vortex (O) within a fluid (E), where the spin velocity of O is proportional to the frequency of waves of the fluid striking O's surface. The lower the ratio of impinging waves to one spin of O, the smaller the scale of time specified by the vortex, the state of O being proportional to some set of past waves of the surrounding field, and, given the model of time discussed above, the continuity of the time-flow of the E-O field must be seen as creating a 4-D structure.

3.5 The External Image

Let us explore more closely then the solution Bergson proposed to the origin of the external perceptual image. Continue the transformation on our gedanken fly. It is currently perceived as moving slowly, flapping its wings. With another increase in the body's energy state, it could be brought to the point of motionlessness - an "immobility." Increasing yet further (in principle) it now becomes an ensemble of "particles" in motion; these themselves become "immobilities," and transform in turn to ensembles of new objects - "sub-particles" - in motion, etc., at each phase the participation and interactions of the "particles" as phases of the surrounding field becoming more apparent. If we extend the transformation of the space-time partition logically to its endpoint, placing successively smaller scales upon time, we arrive at a state of the holographic manifold we can term the null scale. Bergson termed it *pure perception*, the hypothetical point where there is absolutely no "admixture" of memory - for there cannot be two events to juxtapose. This is the point of the smallest imaginable scale of time. At this point our delineation of separate "objects" in "motion" must cease. We deal with an undifferentiated field, the precise boundaries we draw for "objects" being only a function of the possibility of action and of a scale of time. The "fly" has become a "pulse" in the field. But equally so has our body become. The distinction we make between the body/brain as a knowing or perceiving subject and the fly, as object, cannot be on the basis of space.

For the sake of an approximate realization, we can conceive of this field, at the null scale, as comprised of a set of "point-fields" p_i (Figure 3). Assume each field-element connects with and modifies with some "strength" every other field-element (including itself), and does so instantaneously. The activity pattern or (frequency) values of the set of fields will comprise a vector F. Let the increment in connectivity strength, Δp_{ij}, be proportional to the product of the activities F_i and F_j, i.e., a product of the effect of each point-field upon every other. This is in effect a “neural net” model (e.g., Anderson et al., 1977) of the universal field, but it will serve the purpose, and even carries some sense of an implicate order. If at t_1 there is a pulse of activity in the field, we obtain a matrix of connectivities:

$$S_1 = F_1 \times F_1^T. \qquad \text{(T for transpose operation)}$$

S_1 is the matrix of instantaneous space-time connectivities. It represents the instantaneous response of each field-element to every other field-element. In effect it represents the “pure perception” of the null scale and it implies in turn a fundamental form of <u>awareness</u> defined throughout field. At t_2 there is another pulse of activity through the field and a new matrix, $S_2 = F_2 x F_2^T$. As this field develops over time, we obtain a series of such matrices, and the matrix:

$$ST = S_1+S_2+S_3...$$

The summation sign denotes the "dynamic addition" effected by the field over time. As the discrete "instant" is as equally a purely conceptual entity as the discrete object, so each state, S_i, is not mutually external to the next, but interpenetrates the next, forming a dynamic, organic, continuous development, the best model of which is, as noted, the unfolding notes of a melody. As such, in ST, as noted, there is already defined the most fundamental form of <u>memory</u>. Each element of ST now represents the entire history of the field insofar as it has been affected up to some point represented by a given S_i. Let us be aware here that we must regard ST in what follows as a truly dynamically transforming matrix. It is an approximation (very poor) to the "holomovement" of Bohm.

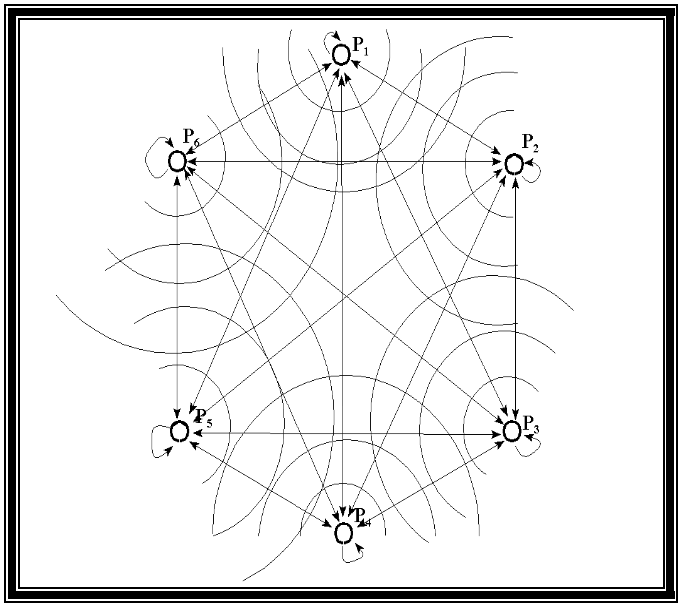

Figure 3 A mini-universe of six radiating point-fields. Each field connects to or influences all the others and itself.

Since Bergson's solution entails a fundamental reorganization of the projective holographic analogy to vision proposed for example by Pribram (1971), we must consider again the analogy and the source of its appeal. Pribram (as did holographers, Caufield and Lu, 1970) asked how light information could be recorded upon a hologram-like brain, then re-projected to form the image we have of the "World-Out-There." Thus we visualize a reconstructive wave beaming through a hologram plate and reconstructing a wave specific to the original source. The natural tendency is to see the brain as the holographic plate and thus to locate identity at the plate. Since we can perceive our legs, arms, etc., this position creeps up the plate as it were until we are satisfied to use some small portion of it. The reconstructive wave nicely specifies sources external to this portion of the plate and we are almost satisfied to place a mystical eye behind the plate to view the reconstructed waves. But who is it that is now viewing the reconstructed image? Do we now invoke an "image processor?" Yet all the information in the image was already in the hologram! We are struck by the specter of the homunculus and its regress. It is a regress that has plagued theories of conscious perception in one form or another continuously.

Let us perform the following intermediate transformation. For the reconstructive wave, substitute the brain itself; for the hologram, employ the universal field. We must make the assumption (a subject for a future proof) that this modulating or reconstructive wave can be supported by the dynamics of the brain. Now let this body/brain, conceived as a sub-matrix of point-fields within the universal field (ST), resonate or respond to this field. Since the action/tuning parameters abstractly reflect the same invariants defining the environmental (E) portion of the field, the structure of this resonance field (O) is "isomorphic" to E. Yet the energy state of this system is such that its response is proportional to a (normally vast) set of past states of the field and not to the instantaneous states of the field wherewith we initially started. This is because O can be conceived as a high dimensional vector of neurons firing at frequency values which are a function of the energy states of the particles comprising this system. As these energy states rise, the rate of transformation of this vector increases, lowering the ratio of the rate of transformation of the environmental vector E to that of O. To "perceive" the null scale, i.e., were we able to raise O's energy states sufficiently, the ratio would be nearly 1/1, the degree of this proportionality varying as the energy state. As the ratio (E/O) rises, in our gedanken mode, from this null point, we generate increasing scales: from a pattern of electron motions, the fly begins to coalesce as fly - an immobility - then slowly move its wings, then become the blur of our normal scale. We thus have a natural scaling of E/O.

In our reorganization thus far wherein we have expanded the holographic plate throughout space and placed the reconstructive wave at the body/brain, we have left identity unmoved. But this helps not in clarifying the origin of the external image. The reconstructive wave/resonance field of the brain, though (at best) isomorphic in structure, appears nothing like E, nor is the brain seeing an image. Nowhere, in the dynamical systems description of the brain is there found anything like the image we have of the external world. For the brain, there is only the modulatory/dynamical description of its processes. Let us continue the transposition. Thus we locate identity over the entire universal field, for we have said that in ST there is already a fundamental memory/awareness defined throughout the field. Considered as a system of point-instants, where each point reflects the influence of every other, we have neither scale nor differentiation defined for this identity. Now we have defined the existence of modulatory systems organized for action within this field, residing at a particular energy state. As opposed to point-systems whose modulatory states specify the entire field over the entire history of the field, the states of these action-oriented modulatory systems specify a closed system of possible action within the field defined at a specific scale of time. They are *specific* to a transformation or modification of the fundamental perception of the field defined throughout with respect to the null scale. The image of the external world is therefore, in actuality, a limitation - a subset or specific form of awareness of the universal field. Ground surfaces, object surfaces, boundaries, the motions and transformations of these surfaces constitute a uniquely defined transformation (or sub-matrix) of awareness within the field itself - a specific form or sub-matrix of the history or change of states within the universal field. Simultaneously, due to the very means by which this modulation is effected, this sub-system (E) displays the possible future action of a subset (O) of the field within itself. This simultaneous specification of symmetrically scaled past and future defines the "present" state of this closed system. Ultimately, as Bergson noted, an identity is focused on the body as the invariant system within the E-O matrix (1896, p.44).

Such, I believe, is the derivation of the external image within Bergson's holographic model. In the process, the meaning of his statement unfolds: "Questions relating to subject and object, to their distinction and their union, must be put in terms of time rather than of space." (1896, p. 77).

4.0 Gibson and Bergson

Gibson has argued that perception is *direct*, that it occurs without intermediary of some code or coding system (to be interpreted or unfolded as the "external world" by some homunculus) or within some "theater of consciousness" within the brain (1979), that properties of the optic array "directly specify" properties of the environment, that properties of the environment taken in reference to action capabilities, termed affordances, are intrinsic features of perception. But beyond this set of concepts, Gibson does not choose to account for the origin of the external image. How the dynamical patterns of the brain that support an affordance, e.g., of a surface-supporting-walking, are transformed to the experience of an external image of a floor is left unexplained. Gibson's optic array is truly unimaginable in the root sense of the term – it cannot be imaged. Any given array is the convergence of all possible reflected rays, reverberating as it were in a steady state (1979). Though carrying information, it in fact, just as a hologram, looks nothing like the environment. How the brain's resonant specification turns this unimageable array into an image of the environment, is not discussed. Even Gibsonians subtly create from these two utterly unlike terms - array and resonant specification - the experienced image. In essence, Gibson had gone as far as Bergson's vision of perception as the display of an array of possible action, without the context of the holographic field or the time-relation of subject/object.

Bickhard and Richie (1983), in defending Gibson against his detractors, have argued that the best interpretation of Gibson's theory is an interactive one: information on the functional properties of the layout can be directly picked up via the states of an interactive system. Gibson (1966; 1979) saw the brain as a dynamically interactive, resonant system, supporting a time-extended, circular process of adjustments to information, precisely because the invariants to which the brain is responding, particularly invariants defined over time, e.g., the point of optical expansion over a flow field, cannot be transmitted as pieces or bits of information over the nerves. In a completely Bergsonian sense, such a time-defined piece of information cannot exist at any one point of space or time in some trajectory through the nerves. As noted, Gibson's resonance vision generalizes or expands naturally with the advent of the dynamic systems approach (Cf. for example Clark, 1997) as a form of chaotic resonance, but this (interactive) model of the overall dynamic (and perhaps chaotic) state of the brain supporting its "specification" of the environment only maximizes the gap between brain dynamics and our phenomenal experience of the external world (and should be an evident dilemma for the dynamical school in the future). Yet, from Gibson, there is definitely no "theater," no homunculus to interpret this resonant information as the experienced world. Something is missing, and the fact is, Gibson's model, to truly make sense, must assume the holographic and subject/object frameworks of Bergson.

O'Regan (1992) is indicative here. Noting that an entire page of surrounding text can be changed during a saccade without notice while someone is reading as long as the 17-18 character window the eye is focused upon is undisturbed, he opts to conceive the environment as an "external memory store" to explain the persistence of the perceived world during saccades. This does not explain how the world-as-memory-store ever becomes (or became) the persistent external image. If we assume the holographic field, then we can see that the overall dynamic resonance pattern of the brain will not be affected by a substitution of the surrounding text during a saccade with its minute (44 bits?) information gathering capacity, the brain's specification yet being to the same states of the past.

4.1 Invariance and space-time partitions

The virtue of the physical concept of the space-time partition arose from the fact that it allowed physical laws to remain invariant over all such partitions. Two observers in two different partitions would yet find themselves using the same laws to describe physical phenomena, e.g., d=vt. It is the invariants, preserved under space-time transformations, that are the realities of the relativistic universe. We have already seen in effect that a virtue of Gibson's (1950; 1966; 1979) emphasis on invariance laws is that it is these laws that can indeed hold across partitions, defining perceived events, and that this emphasis on invariants defining perceptions has its logical extension in the relativistic implications of virtual action.

Consider again the rotating cube. We saw that as the rate varies it transforms through figures of 4n-fold symmetry, from a cube and a rotation through a cylinder surrounded by saw-toothed edges in rotation, through a cylinder surrounded by a fuzzy haze of some width. Remembering that the information for the cube's shape is defined over its symmetry group, it was apparent that as long as the number of rotations per unit time is sufficiently small, our perceptual systems can process or respond to the invariant defined over this transformation which carries the information for the form of the cube. But as we increase the rapidity of the rotation, this form is no longer specified. The perceptual systems cannot respond to an invariant defined over so small a fraction of time, and they "slip" as it were to another level of invariance, due perhaps to the natural bifurcations of a dynamic system. Increasing the velocity of the processes supporting the resonance states of the brain should effectively cause the system to respond to invariants defined over smaller scales of time.

With respect to observers then in different partitions, let a cube be rotating at such a rate as to specify a figure of 16-fold symmetry for Mr. A who is in our normal space-time partition. Mr. C, whose energy state is very low, perceives a figure of infinite symmetry - a cylinder. Mr. B, in a higher energy state, perceives a figure of 4-fold symmetry in rotation - a cube - while Mr. D, in yet a higher state, perceives a stable object. All perceive figures of 4n-fold symmetry by operation of a perceptual law invariant across partitions.

Imagine a relatively "slow" event - the change/aging of the facial profile. This event can be mathematically characterized by a strain transformation upon a cardioid (Pittenger & Shaw, 1975). Now let us compress this slow event, imagining the aging as a very rapid event unfolding before us, as it would be for Mr. C who is in a low energy state. For the virtual action principle to hold in this partition, where aging is now a "fast" event, Mr. C's action systems, just as in the example of the cube, must be tuned by precisely the same information specifying the event to us, i.e., the strain transformation, if he is to appropriately modulate his hand to grasp the rapidly expanding, transforming head in mid-motion.

In the auditory realm, Jones (1976) has described a similar invariance principle that applies to the perception of serial order over a sequence of sounds, either for tones or, she argued, for the phonemic sounds composing the speech stream. For example, consider the notes of the whole tone scale, for each of which we give a numeric symbol:

C, D, E, F#, G#, A#, C" (where C" is two octaves above C)
1, 2, 3, 4, 5, 6, 1".

Then we can consider the following series or pattern of notes, where the notes sound at the rate of one note/second:

(1) 1 2 4 5 1" 2" 4" 5"

The hierarchical structure of this pattern is shown in Figure 4. At the rate of one tone/second, this pattern will be perceived in the serial order presented above. We may speed this pattern up in time - the relations in terms of time intervals between the notes remain invariant. However, at the rate of 10 tones/second the pattern breaks apart in a lawful manner - a phenomenon known as "streaming." At this rate, two sub-patterns are perceived, one interleaving - as figure to ground - with the other:

1 2 4 5
1" 2" 4" 5".

Note that in pattern (1) the change in pitch varies. At level N1 of the hierarchy, there is a one step difference, e.g., between notes 1 and 2, or 4 and 5. At level N2, there is a three step difference, e.g., between notes 1 and 4, and at N3 we have a six step difference. The principle stated by Jones is as follows: whenever a sequence in time is

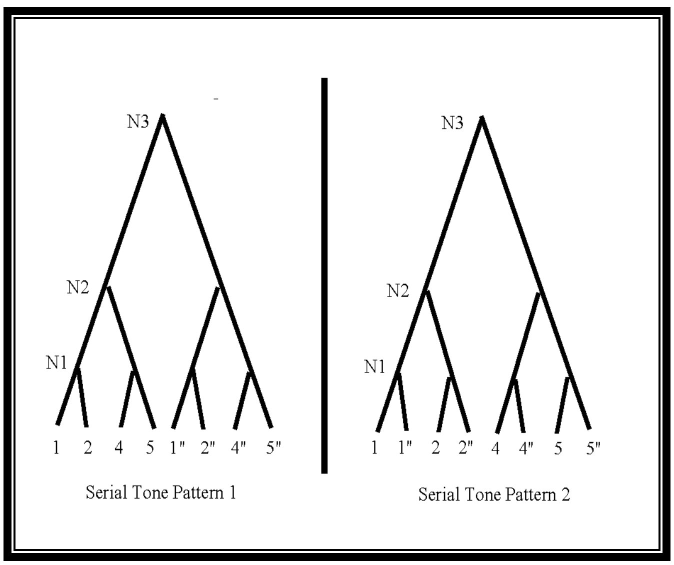

Figure 4 The hierarchical structure of two tone patterns. Tone 1" is two octaves above tone 1. (After Jones, 1976)

translated along the time scale, the amount of change (Δ) tolerable in any dimension d, (in this case pitch) at some level n of the pattern's structural hierarchy, is dependent on the time period ΔT corresponding to that level. Thus there is a proportionality constant defined at each level of the hierarchy, $k = d/\Delta T$, which must hold between some lower and upper limit. When this upper or lower limit on k is exceeded, i.e., the dimensional change (pitch in this case) is too great relative to the time interval, the serial order of the pattern degrades downward to the next level of invariance where k yet holds. In pattern 1, the "breakage" occurs at the top level (N3) where we find the pitch difference is 12 steps, e.g., from 1 to 1"; the serial structure at level 2 of the hierarchy and below are yet preserved. Consider pattern 2, with hierarchy also shown in Figure 4.

(2) 1 1" 2 2" 4 4" 5 5".

This order is perceived at 1 tone/second, but at 10 tones/second, because of the large dimensional difference at the first (N1) level of the hierarchy, e.g., an octave between 1 and 1", it breaks apart immediately at the lowest level of the hierarchy and is perceived as two simultaneous patterns:

1 2 4 5
1" 2" 4" 5".

The “enfolding” of the orders here attunes, I believe, with Bohm’s (1980, p. 199) observation that on listening to music, “one is directly perceiving an implicit order.”

Symmetrically, we should be able to effect the same changes in perceived serial order by altering the velocity of processes. The relation of perceived pitch to the body's action systems can also be argued to exist, pitch being more in this view than a matter of a "frequency" analysis by the auditory system. Bergson (1896), as an example, argued that the perceptual dimension of "high-low" in tone ultimately relates to the structures of the vocal tract involved in the body's own production of tones of varying pitch.

This invariance principle is equally valid for the phi motion discussed by Dennett and Kinsbourne (1992) in the context of the Multiple Drafts model, where two spatially separated light flashes, if close enough in time, are seen as the movement of a single point. The perception of a motion here is again the body's adherence to an invariance law acting across scales (see Grossberg (1995) for a dynamical model), making the apparatus of “micro-takings” unnecessary.

4.2 Gibson on short-term memory

Gibson’s resonance model of the brain held an inherent skepticism toward standard models of short-term (STM) or immediate memory. He severely critiqued (1979) STM models of the perception of a time-extended event, e.g., the buzzing fly, that implicitly relied on images or “snapshots” accumulating in memory, somehow sequentially retrieved, and somehow integrated to form a perceived “present” event, insisting that “memory” as a power of the brain was not needed at all for this. The brain’s resonance to invariants over the time flow of the event is all that is required. He had stated his problems with STM succinctly:

> The seemingly innocent hypothesis that events are perceived has radical implications that are upsetting to orthodox psychology. Assuming that shorter events are nested within longer events, that nothing is instantaneous, and that sequences are apprehended, the usual distinction between perception and memory comes into question. For where is the borderline between perceiving and remembering? Does perceiving go backwards in time? For seconds? For minutes? For hours? Where do percepts stop and begin to be memories, or, in another way of putting it, go into storage? The facts of memory are supposed to be well understood, but these questions cannot be answered. (1975, p. 299)

In Bergson’s model there is no borderline. Perception is of the past - a partition of the continuous flow of the holographic field. The dynamic state of the brain is specific to a scaled subset of past states of this field, while the 4-D extent of perception is determined by our scaling principle, i.e., by the possibility of *future* action. The (cognitive) relativity principle together with Bergson’s model of time makes clear that we cannot say that the "past" is that which has ceased to <u>exist</u> - that we have somehow a point at which we can irrevocably divide past from present (and therefore the point of storage), nor can we assign the degree of time-extension of perception to some mythical attribute of short-term or immediate memory. The inherent variability of space-time partitions denies this possibility. Consider again Messrs. A, B and C. Mr. A is watching the fly in our normal partition and thus sees a multiplicity of wing oscillations summed up in a single visual display - a blur. Mr. B, in a higher energy state, perceives motions of the fly's wings corresponding to minute fractions of an arc - the scale over which B can act. For B, the motions of the wings that comprise A's current vision of the present are in the remote past - "five wing beats ago" seeming quite a long time indeed. Does B have the right to claim that these events, which form part of the present as far as A is concerned, are in fact non-existent, or that A is relying solely on the power of his STM? For C, in a lower energy state, we would see that events in the remote past for A are now part of the structure of C's present, for C sees the fly's entire life history as a brief blur. It is clearly a matter of the scaling effected via a dynamic system.

Turvey (1977b), commenting on the logical basis of STM, noted that the intuition behind it is of a holding area for the needed snapshots of an event - a compression of an event occurring over a timeline T to some smaller timeline t - ultimately, as Bergson noted, a confusion of real time with abstract space, a transmutation of a motion to a set of spatial positions, as though we took a series of high-speed snapshots (e.g., of the fly) and laid them out on a desk, thus "capturing" the event. The logical problems inherent in this are extensive. What is the scale of time of these snapshots? What determines this scale? How is motion (of the fly) registered? Do we invoke an internal "scanner" to scan the immobile snapshots? How does it (the scanner) now register motion?

As a final problem, Turvey noted in essence that a choice of scale, i.e., a sampling rate for the snapshots, leads to a complete breakdown in handling invariance laws. As noted, a rotating wire cube when strobed at integral multiples of its symmetry group period is yet seen as a rotating cube, while if strobed out of phase with this symmetry period, it is seen as a distorted, wobbly figure. How could the sampler be pre-adjusted to the symmetry period and rotation rate of the object? What if there were two cubes rotating at different speeds?

The conclusion is that there can be no sampling mechanism. Perception is the abstraction of invariance over the continuous flow of time, a time where discrete "instants" are unreal, conceptual divisions, a time which is the "succession without distinction" of Bergson.

4.3 A Bergson/Gibson memory model

If Gibson has a resonance model of perception, I think it safe to say that he never developed a corresponding memory model. He disliked the storehouse metaphor of memory, in fact ridiculed the idea that the past ceases to exist unless stored in the brain (1979), seeing it as misplaced and outmoded physics (1966). Still he gave no compelling model to replace the storehouse, no model of “direct” memory. But if Gibson’s model of perception is (in effect) Bergson’s, the difficulty is clear: perception/experience is not localized to the brain, and if not so localized, then it cannot be exclusively stored there. Bergson’s model however provides a framework in which Gibson is readily extended.

In terms of remembering past events, Bergson spoke metaphorically of the brain, embedded within the four-dimensional holographic field, acting as a sort of "valve" which lets certain past events into consciousness depending on the array of possible bodily actions the brain is preparing. A present event which causes the brain to prepare a certain array of possible actions allows events in the past related to similar action patterns to enter consciousness. The modulatory state of the brain then serves not only as a limiting function on the 4-D extent of the past, i.e., as determiner of the space-time partition. Approximately the same resonant state can recur, roughly the same configuration of action systems can be activated. Thus one may perceive/experience a given space-time event (E_1), and move on to another (E_2) separated both in space and time from the first, yet if a resonance state were to occur at E_2 such that the 4-D "hologram" were modulated properly, E_1 would also be reconstructed. Past experience would then appear infinitely “portable,” yet our suitcase would not have to be the brain, for the information for the entire past would be available for modulation at any point of space-time. Memory losses – amnesias, aphasias, etc. – as Bergson argued, would be due to damage to the ability to assume the complex modulatory patterns required. Yet memory experience would also be individualized, such that the experience of each body would not be accessible to any other body in general, for E_1 would be an event unique to a particular modulating system whose state at that point in time would be the reflection of its entire history. The unique "flow" of "presents," each present state being the reflection of the preceding series, constitutes the identity of the individual. Each present experience then contains a unique aspect - the identity of the individual. Identity, it can be said, as reflecting a system whose each state reflects the entire past, constitutes the reference wave. E_1 then could be reconstructed only by the system which originally lived the experience.

There is a symmetry then of perception and memory. It implies that the laws determining the reconstruction or "redintegration" of past events will then be the same invariance laws determining perceptions. Thus the event E_1 was defined by a set of transformations and structural invariants which determined the body's modulatory state and therefore the perception of the event. To reconstruct this event, it is necessary to move the body into a modulatory state defined by the same invariance structure, whether this be effected through an event defined by a similar pattern (E_2), an abstract rendering of these invariants (e.g., via computer), or moving the body into an action (motor) state defined equivalently.

Suppose we experience several events, E_1, E_2,...E_n, where each event has a highly unique description in terms of its transformations and invariants. This is analogous to recording on a hologram a series of wave fronts, each with a unique reference wave, f_1, f_2,...f_n. Now we know that the more unique the reference wave, the easier it will be to modulate the reconstructive wave to varying frequencies of sufficient fidelity to reconstruct each different recorded wave front whenever we please. Similarly, we will find that the more rich and unique the transformational/structural invariance description of a series of experienced events, the easier it is to move the body/brain into a modulatory pattern sufficiently precise to reconstruct each separate event when we please. Thus the effectiveness of dynamic imagery for example in paired-associate learning, where an event-image is formed for “knife-soap” (the knife cutting the soap), “hammer-rock” (the hammer smashing the rock), etc., for each pair.

What we are describing here is a general model for the redintegrative problem which has been with psychology since Wolff coined the term and framed the problem in 1732. A certain waving of a field of grass brings back a patrol in Vietnam. The word “knife” reconstructs an image of a knife cutting soap. The redintegrative law is as follows:

> An event E' will reconstruct a previous event E when E' is defined by the same invariance structure or by a sufficient subset of the same invariance structure.

It is assumed here that E', the environmentally specified event, evokes the same resonance state or modulatory wave defined over the brain as did E. The premium here is placed on the description of event invariance structures, an effort well begun by Gibson. We can describe an event invariance structure as a characterization of both the structural invariants and the transformations over which the event is defined (Shaw & Wilson 1974). By "transformation" is meant that information specific to the "style" of a change, e.g., the information defining bouncing, rolling, rotating, expansion, contraction, opening, etc. By "structural invariant" is meant that information specific to the thing or object undergoing the change, e.g., the ball, the balloon, the dough, the cube. In the case of the facial profile the structural invariant was abstractly defined mathematically as a cardioid. The transformation was defined mathematically as strain. In the case of the flow field, we have the lawful expansion of the field according to the relation $v = k/d^2$ as the transformational information, while there is information specific to the thing undergoing this transformation, e.g., a texture gradient specific to a field of grass.

Glenberg (1997), dealing with the same redintegrative problem and representing the growing appreciation of bodily action in the process of memory (inherent in Bergson), goes no further than the notion of a “mesh” between “patterns of action with patterns of past interaction.” It has been difficult for psychology to move to the obvious formulation of the redintegrative problem incorporated in the law above, depending as it does on the global modulatory pattern, for the significance of the modulatory wave is that of the dynamical system of the body/brain as a whole as a reconstructive wave within a hologram. But to make sense of this requires the framework on time and mind laid out above, for the problem of the origin of the “memory image” is essentially the compliment of that of the external perceptual image (Cf. Robbins, 1976).

This is but the barest sketch of the possibilities in Bergson’s model when conjoined with Gibson’s, and the barest sketch of Bergson as well. I have focused more on a picture of the whole rather than on detailed arguments for a part, and seemingly perhaps more on perception/memory than on consciousness per se, though it should be abundantly clear from the foregoing that no theory of consciousness is grounded without solving the problem of perception/memory, that a theory of perception/memory is a theory of consciousness. This framework is a foundation for the understanding of the passive aspect of consciousness, the most basic point of what has been termed the "hard" problem, i.e., why there is the experienced world-out-there, located in depth, in volume. The positive aspect of consciousness, the "very hard" question (and there are many more), i.e., the problem of will and voluntary action, of how I will to and move even my finger, is untouched. Even Bergson had only small offerings. Its profundity, given the foregoing, should be apparent. Yet I believe that as a beginning, the perspective of Bergson is both powerful and unique and deserves serious consideration in theories of conscious perception.

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